MACHINERY.

June, 1903.

THE EVOLUTION OF THE CHANGE GEAR.—1.

A STUDY OF THE UNITED STATES PATENTS ON LATHE CHANGE GEAR DEVICES.

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The question of the change gears of lathes and the great amount of time and inventive genius that has been devoted to the matter in the last few years would seem to render the subject one of considerable interest to the men who design lathes, the manufacturers who build them, the men who buy or use them, and the men who are interested in the obtaining of patents upon their various and almost multitudinous devices.

The matter has been taken up with the view to ascertaining what there may be in this line which has been secured in the United States Patent Office; to give diagram illustrations of the prominent features of each device in itself, and to compare and contrast its various claims to usefulness, both in a commercial and in a practical way, with other inventions of its class.

It is undoubtedly true that there may be very commendable devices on the market to-day, put forth on a quasi claim of being patented, which have never seen the inside of the Patent Office, except possibly to be put on the immense list of rejected applications.

The careful and methodical reader is assured that although the copies of no less than one hundred and fifty-six patents have been considered, covering as they do many phases of variable speed mechanism, the twenty-seven patents hereinafter described and illustrated contain all of the subject matter from the patent of Bancroft and Sellers in 1854 to that of Johnson, August 12, 1902.

And in reviewing these various patents the first consideration has been to get at the *germ* of the invention, to illustrate its good points "for all they are worth," and in comparison with others to give all due credit which the mechanical knowledge of the writer feels to be fair and just. If inventors feel that their devices are underrated they are heartily assured that there is no desire to in any way belittle their work, but rather to bestow "honor where honor is due."

It would seem appropriate just here to mention some of the points which impressed themselves on the mind of the writer during the long and careful consideration of this subject. Of course it is expected that there will be those who will not agree with the writer's opinions or deductions as to the construction or merit of the various inventions. To these good people there is one thing to be said. It is this. When you don't like what is said and you feel like criticising these articles (or any statements made in them) which are contributed in an honest effort to advance the general knowledge of the subject; don't get indignant and rush into print. Work off your surplus bile in some other way, and when you have arrived at the blissful condition of superiority of judgment necessary for the occasion, sit down and write an article on the same subject a great deal better and a great deal more correct than the author has done. It will serve several useful purposes. The general public will get the benefit of your special knowledge, the editor will pay you well for it, and you will have eased your mind; thus combining a public duty with pleasure and profit to an eminent degree.

One of the features in patent drawing which strikes a practical mechanic very forcibly is that very few of the drawings are so made that even an operative model could be made from them, much less a practical working machine, without supplying much in the way of mechanical detail and design. Various views and groups of parts are found utterly impossible to assemble as they are drawn. Sometimes in two adjacent views one is reversed and not a similarity of form or the presence of reference letters to show the fact. In one case a sliding piece was required to move fifteen inches and had formed upon it a rack which could not be cut with over three teeth to an inch, and this was operated by an eight-tooth pinion on the end of whose shaft was a lever which could move only through an arc of 90 degrees, hence the rack would move less than an inch instead of fifteen inches. And so on *ad infinitum*.

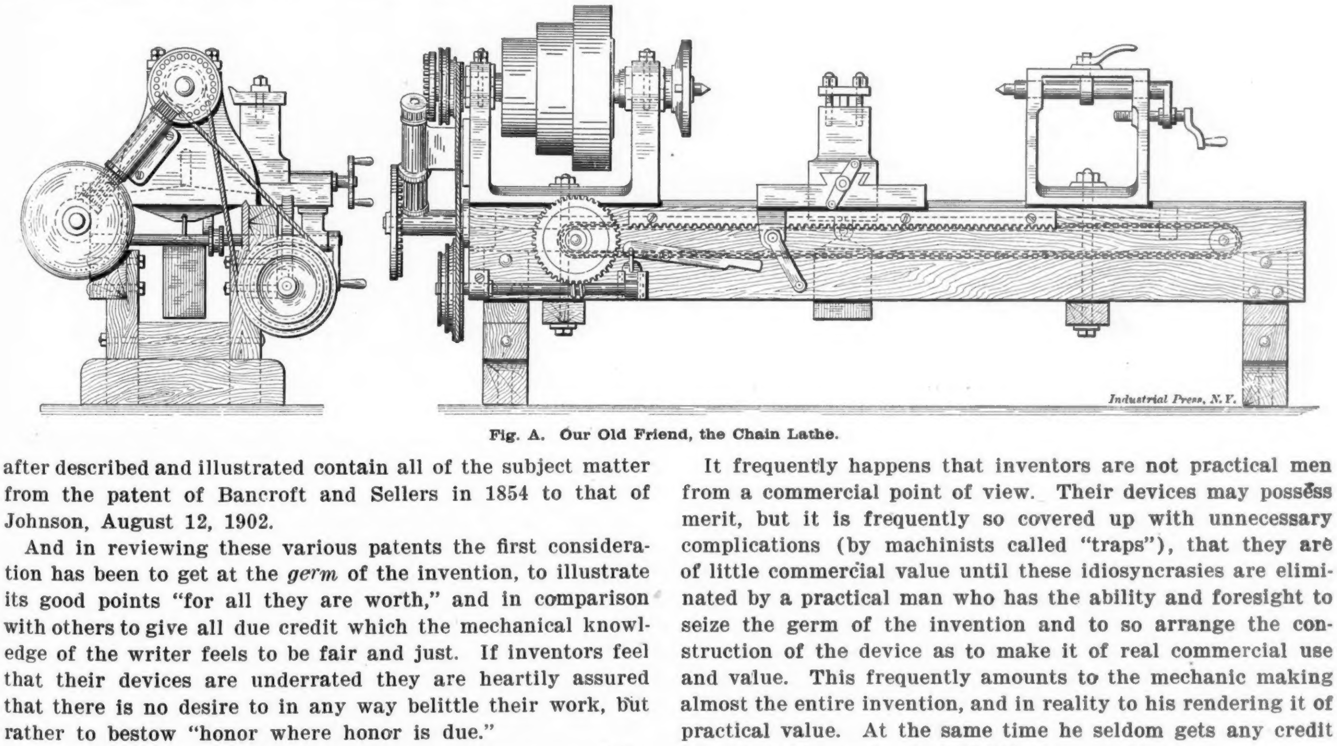


Fig. A. Our Old Friend, the Chain Lathe.

It frequently happens that inventors are not practical men from a commercial point of view. Their devices may possess merit, but it is frequently so covered up with unnecessary complications (by machinists called "traps"), that they are of little commercial value until these idiosyncrasies are eliminated by a practical man who has the ability and foresight to seize the germ of the invention and to so arrange the construction of the device as to make it of real commercial use and value. This frequently amounts to the mechanic making almost the entire invention, and in reality to his rendering it of practical value. At the same time he seldom gets any credit for what his mechanical ability has produced.

From time immemorial it has been one of the vexing questions in the blacksmith shop as to which was the first of the blacksmith's tools, the hammer or the tongs. If the question was asked, Which one of the machines was first used in the machine shop, nearly every machinist would unhesitatingly say, the lathe. And while the lathe is also probably the oldest of machine tools, it is the most important in many respects today. Many of the other machine tools might be spared and the work done in some other way. But the lathe is the one indispensable machine that the machinist *must* have. With it he can turn, bore, face, mill, plane, slot, and in fact do almost every kind of work done by any machine tool in the shop. It is verily the king of machine shop tools. And yet, while

it is probably the first machine tool devised, it is only in comparatively recent years that it has arrived at anything like its present state of perfection.

In considering the subject of change gear devices for lathes it may be well to refer briefly to the early history of turning lathes and then to their later development, not only of the devices for thread cutting, but of the lathe itself. Going back to the early history of the lathe, we know that Theodorus of Samos, B. C., 560, is said by Pliny to be the inventor of turning, but while many believe that this species of "turning" perhaps referred to the "Potter's Wheel," used in forming clay into circular vessels, it is undoubtedly true that the "Potter's Wheel" was known centuries before, since it is several times spoken of in the old testament.

It seems to be a fairly well conceded fact that the first turning lathe ever devised was a very crude affair and consisted of a spindle pivoted to two trees or to blocks fastened to the trees and propelled by a cord whose upper end was attached to a flexible limb of one of the trees, from whence it passed down to the spindle, took a turn around it, and then continued down to a treadle to which the power was applied. It is probable that in its gradual development a balance wheel may have been attached to the spindle and that it was propelled by an assistant. Later the idea of a crank was probably added and some sort of pulleys, most likely grooved ones, were discovered and the convenience of increased speed made possible. Thus far it is likely that the use of the lathe was for turning articles of wood or ivory, but it was not a long step to turning articles of metal. Thus these simple mechanical contrivances were devised for the use of the early mechanics, who in their gradual improvements must have hit upon the idea of screw threads for bolts used in fastening their work together. While it is probable that Archimedes, B. C. 287, had an idea of the form of a screw it was a long while after his time before the idea was applied to the formation of screw threads as we know them to-day. It is probable that the first screw threads were made on wood and that they were "chased" with a hand tool. The writer remembers an old shop in the country where, in a certain form of woolen spinning devices a worm and worm gear was wanted and it was made by wrapping a piece of paper around the turned cylinder which was to be the screw, and cutting through this with a knife so that it would become the exact development of the surface of the cylinder. This paper was then laid off for the pitch as shown in Fig. B. It was then glued around the cylinder and the diagonal lines became the developed screw thread. Then with a fine saw, a chisel and a file the thread was cut in a proper V form. The wooden wheel was spaced off and the teeth cut in a similar manner, not with a curved pitch line, of course, but straight as in a spur gear. It was surprising what an amount of wear these crude worms and wheels would stand.

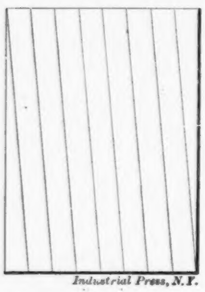


Fig. B. Development of Screw Thread.

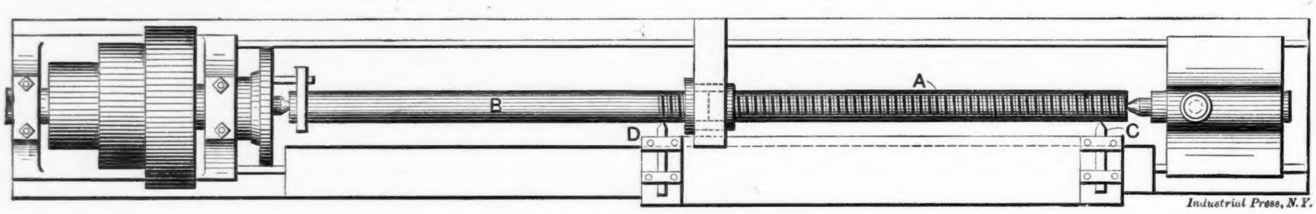


Fig. C. Early Method of Cutting Threads.

Following along in the gradual development of mechanical devices threads were cut on metal, "chasers" still being used for this purpose. With the crude hand tools then in use, this was a very slow and laborious process until some genius more far seeing than his fellows developed the idea of cutting a thread from one already made, on the principle of the "gauge lathe." This idea is illustrated in the accompanying sketch, Fig. C, in which such a lathe is shown in plan, and in which *A* is the screw already cut; *B* is the piece to be threaded, adjusted in proper supports and the one driving the other; a slide carrying at one end a former point *C*, engaging the thread and at the other a cutting tool *D*, for chasing the thread. From this device doubtless proceeded the idea of making the screw a permanent part of the lathe, with a nut which was attached to the sliding part, or carriage. This had been preceded, probably, by other means of moving the carriage for plain turning, such for instance as the old time "chain feed." The "master screw," "traveler screw," or "lead screw," as it was variously called, was for a long time placed at the back of the bed and in the earliest examples was revolved by gearing made by inserting pins in the face or in the edge of wheels or disks. It is altogether probable that for a long time only one pitch of thread was cut by a "master screw," and that when another pitch had to be cut another "master screw" was required, as the "master screw" revolved at the same rate of speed as did the head spindle of the lathe.

Then followed the idea of revolving the "master screw" at a different rate of speed from that of the spindle for the purpose of cutting a different pitch of thread from that of the "master screw." When this was once done, it was easy to see that if two pitches of thread could be cut with one "master screw," any other number of threads might be cut by similar means. In order to cut both right- and left-hand threads, as well as to conveniently bring the change gears into engagement with each other, the stud plate (or "quadrant," "swing plate," "yoke plate," etc., as it has been variously called), was devised, with its stud for idle gears and an extra stud for the gear necessary for reversing the motion of the lead screw in cutting left-hand threads. Thus the well known change gears and adjustable stud plate came about and did good service for many years. But the restlessness of mechanics and the ever-present desire for improvements in time led investigating workmen to look for some method by which to avoid even the small labor and inconvenience of changing the gears when a different thread was to be cut.

In order to illustrate some of the earlier forms of lathes the one on the first page is shown. This lathe was probably built about 1830 and was the property of an old Scotch mechanic named Rea, who had a shop about four miles from Plattsburgh, N. Y. The bed was composed of two oak timbers about 5 x 12 inches, bolted to wooden legs, as shown. On the inside of each timber a rabbit was cut, in which were fastened flat bars of wrought iron, set with the edges up, and about ⅝ x 3 inches, the upper edges being chipped and filed to answer for Vs. The head stock was cast with pockets of square form for the boxes, which were fitted by filing, and also had threaded studs of wrought iron cast in the head for holding down the caps over the boxes. The boxes were cast of some sort of a composition resembling babbitt metal. The spindle was of wrought iron and carried a wooden cone of three steps built upon a cast-iron flange keyed to the spindle. The tail stock was very light and had on the rear end of its spindle a downwardly projecting part, slotted to receive the tail screw, which was provided with a crank forged upon it. Both head stock and tail stock were held in place by a single bolt each, passing down through wooden binders (not shown in the cut). The carriage was fitted to the same Vs as the head and tail stocks and had no more pretence to an apron than a bracket carrying a cast-tooth pinion meshing in a cast-tooth rack screwed to the front of the bed. The carriage was held down by a cast-iron weight as in all the old style of "weighted carriage" lathes. A power feed was provided for by the use of a chain passing over two grooved wheels in which were pins for engaging the links of an ordinary "log chain." This was operated by a worm wheel with cast and chipped out

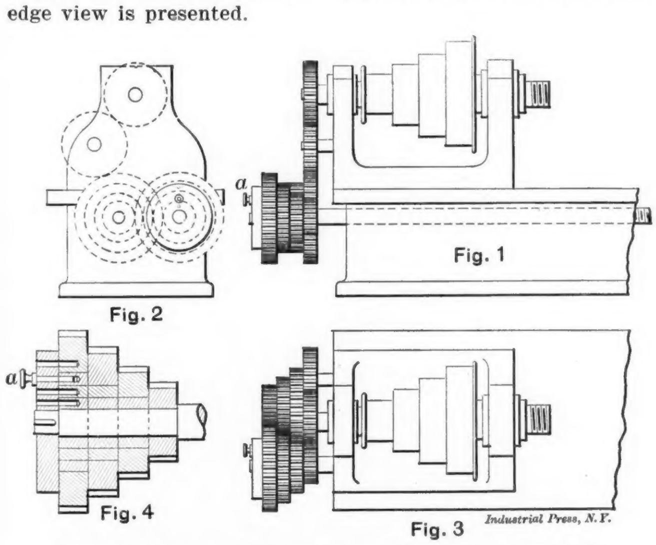
teeth and a worm of only two or three turns of thread. This was driven by grooved cone pulleys carrying a half inch round hand-made leather belt. To stop and start this feed the end near the cone pulley was journaled in a pivoted box, and the other end supported in a vertically sliding box operated by a wooden lever which was conveniently hooked under a spike driven into the front of the bed. This feed mechanism was said to have been a comparatively recent addition to the lathe.

When the writer saw this lathe along in the beginning of the civil war it had an arrangement of change gears with cast teeth somewhat like the more simple lathes of to day so far as its action was concerned; but hanging on the wall in the old shop and carefully treasured as relics of bygone days were the old "pin gears" and "lantern pinions" shown in the engravings. It was noticeable that one of these "lantern pinions" (the lower one in the engraving), was much longer than the other. This was probably to accommodate different sizes of "pin gears" on the lead screw so as to cut varying pitches of threads.

This lathe was in practical use in 1875, and as its old-time Scotch owner quaintly remarked, it was "able for monny a guid turn yet."

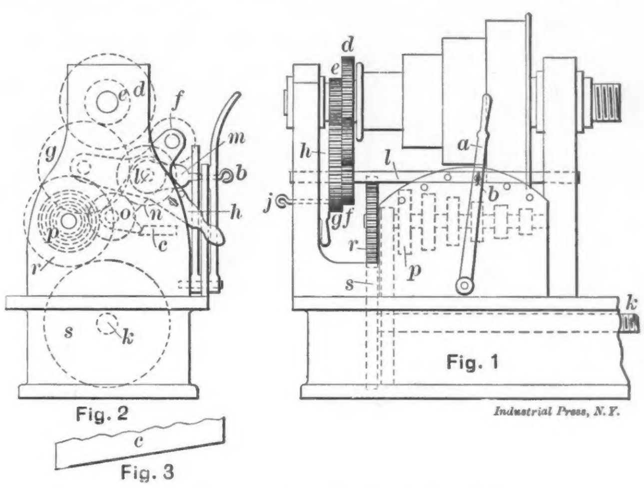
Recurring now to the gradual development of the lathe in reference to the thread cutting problem by the interchange of gears for producing varying pitches, and finally without removing or replacing "change gears," we come to the consideration of the actual evidences of what has been done, and the legal proof of the same as shown by the records of patents in the United States Patent Office. In reviewing the mass of drawings, specifications and claims on these various points, covering the changes invented and proposed, we find many which are for the purpose of changing the rate of *feed* for ordinary turning, and these have been omitted as not properly concerned in the subject of "The Evolution of the Change Gear."

In presenting the drawings of patents to illustrate these articles, it will be noticed that they are in the form of diagrams only, showing in a condensed manner the prominent features of the invention. In some cases as many as four sheets of drawings are here shown in three or four views, for the purpose of simplifying the matter and economizing space. Gears are represented in side elevation by circles of heavy dotted lines and shaded to show their convex surface where the edge view is presented.



Edward Bancroft and William Sellers. No. 10,491, Feb 7, 1854.

So far as we have any Patent Office records of the matter, the first serious attempt made to assemble all the change gears on one shaft appears to have been made by Edward Bancroft and William Sellers, of Philadelphia, Penn., who obtained patent No. 10,491, which was dated February 7, 1854. They placed the change gears directly upon the lead screw, the first or smallest gear having formed upon it a sleeve bored to fit the lead screw, and having fitted upon it the next gear having a like sleeve for the following gear, and so on. These gears were all held in place by a disk fixed to the lead screw Either of these gears could be in turn fixed to the disk by a pin passing through them both. The arrangement in connection with the lathe is shown in the accompanying illustration, in which Fig. 1 is a front elevation; Fig. 2, an end elevation, and Fig. 3, a plan of the Bancroft and Sellers lathe. Fig. 4 shows the manner of forming the gears with telescoping sleeves, and the fixed plate with its removable pin *a*, for bringing any desired gear into action. The first claim of these pioneers in the change gear problem is worthy of careful consideration. It is as follows: "The method of varying the motions of the mandrel and screw-shaft or leader by means of two series of wheels, each series consisting of wheels of different diameters, and all the wheels of one series being connected and turning together, and imparting motion to all the wheels



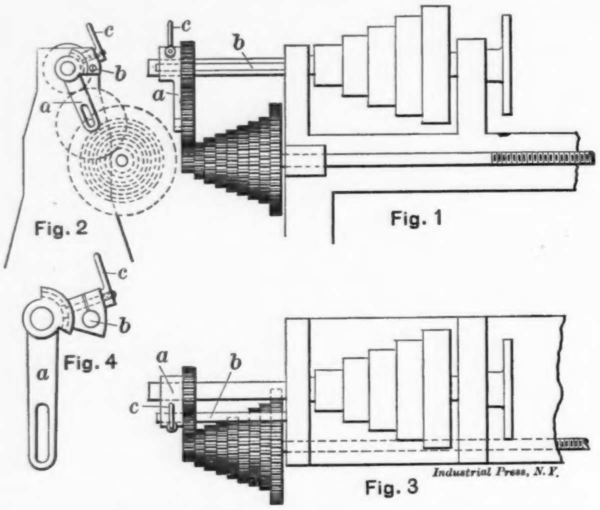
John Humphreys. No. 83,774, Nov. 3, 1868.

of the second series with different degrees of velocity, substantially as described." It will be observed that this claim practically anticipates several of the later devices which have been popularly supposed to be the first of the kind, and whose inventors have been given credit accordingly.

John Humphreys, of Chicopee, Mass., was apparently the next inventor who added much to the then "state of the art" as disclosed in his patent No. 83,774, which was granted November 3, 1868. He appears to have followed Bancroft and Sellers in the idea which years later became so popular, for he says: "I place my gear wheels all on a shaft. ranging from the smallest to the largest, leaving a space between them of about the same width as the wheels themselves." This space was provided so that his connecting pinion journaled in a "traveler" as he calls it, and could relieve itself from engagement with one gear before it came in contact with the next, as he had not provided for throwing it entirely out of gear before moving it laterally, as was done later. Another feature apparently original with him, was that of obtaining an additional series of pitches by means of a yoke, pivoted on the same secondary shaft that his traveler worked upon, and having two idle gears journaled upon it, by which either a small gear or one double the size could be quickly brought into engagement with the gear on the secondary shaft. Both these essential features of Humphreys' patent have figured extensively in most of the later efforts in the attempt to provide for rapid changes of feed or from one pitch to another through a large number. Fig. 1 is a front elevation of his lathe head, showing the shifting lever *a*, held at the desired point by the pin *b*. Fig. 2 is an end elevation showing the essential features. Fig. 3 is a development of the cam-shaped rack *c*, which held the traveling pinion in contact with each gear of the cone of gears as it came into mesh with it. The arrangement for multiplying or reducing the speed by gears of double the number of teeth is shown at *d*, *e*, *f*, *g*, journaled upon studs fixed in the yoke *h*, held in either position by the pin *j*. The lead screw *k* was placed within the bed. Upon the shaft *l*, both the yoke *h* and the sliding lever *m* are journaled and the connecting pinion *n* is splined. The pinion *o* connects with the cone of gears *p*, from whose shaft *q* the gear *r* engages the gears on the lead screw *k*.

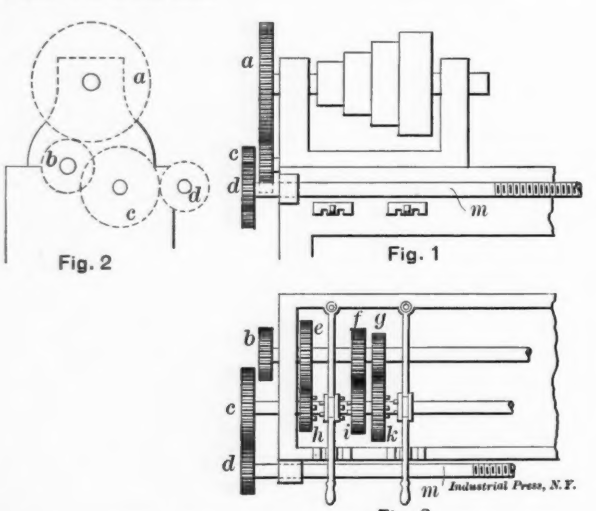
Three years after Humphreys' patent Frederick B. Miles, of Philadelphia, Pa., in patent No. 111,859, granted February 14, 1871, came still nearer to solving the problem by mounting

all his change gears on the lead screw. The end of the head spindle projected far enough beyond the rear box to carry a sliding gear controlled by a "traveler" as Humphreys called it, and having journaled on it an idle gear that might connect the sliding gear with any one of the change gears, at will. It was held in place by being clamped to a rod fixed in the head stock and parallel to the head spindle. He also provided on the lead screw a gear much larger than the change gears for use as a feed gear for a turning cut, there being no feed rod provided for. A front elevation is given in Fig. 1;



Frederick B. Miles. No 111,859, Feb. 14, 1871.

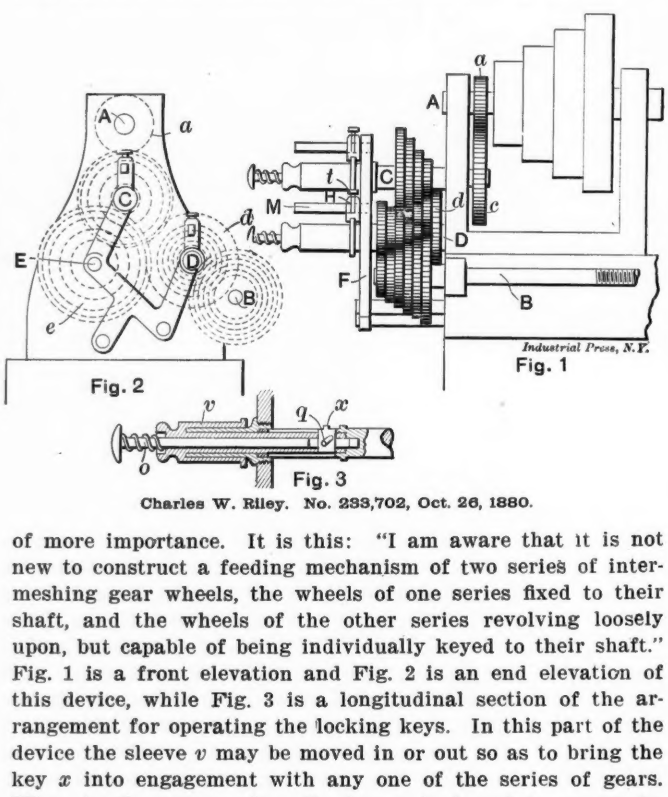
an end elevation in Fig. 2; a plan in Fig. 3, and a detail of the bracket carrying the connecting pinion in Fig. 4. It is not likely from the construction that it was practical, as the torsional strain caused by the pressure of the gears of the cone of gears and the pinion on the head spindle with the connecting pinion would probably have wrecked the device in a short time. But the *idea* was evidently there and only needed developing in a practical manner. The drawing is so simple that it is only necessary to specify that the sliding bracket or arm seen in Fig. 4 is shown in position at *a*, Figs. 1, 2, and 3, and the supporting rod to which it is clamped is shown at *b*. This arm is secured in any desired position by the clamping lever *c* and its bolt.



William Bley. No. 156,758, Nov. 10, 1874.

William Bley, of Reesville, Pa., was the next man to record his ideas in the patent office. He did not add much to the subject, his modification being that of providing two supplementary shafts, upon each of which is mounted a set of change gears in reversed order. One set was fast to the shaft, while the other set ran loose on the shaft and was in turn brought into action by a series of clutches splined to the shaft, each clutch serving for two gears. In this way about three and a half feet of space inside of the bed would have been required for a twenty inch swing lathe. In the drawings, Fig. 1 represents a front elevation of the lathe; Fig. 2 is an end elevation, and Fig. 3 is a plan of the bed showing the arrangement of the supplementary shafts, gears, clutches and the operating levers. The gears *h*, *i*, *k* run loose on their shaft and are connected with it as desired by the adjacent clutch. The gears *e*, *f*, *g* are fast to their shaft and are, of course, each driven by its opposite gear whenever the clutch is thrown into engagement. The driving power to the lead screw is transmitted through the gears *a*, *b*, one of the gears *e*, *f*, *g*, and their fellows *h*, *i*, *k*, and the gears *c* and *d*. In an operative lathe there would need to be many more gears, as the arrangement shown would cut but three different pitches and two more gears would need to be added for each pitch. This would be an elaborate arrangement and scarcely practical, as may easily be seen.

Charles William Riley, of Knoxville, Tenn., next tackles the change gear problem, and the results of his efforts are elaborately shown in the three sheets of drawing of Patent No. 233,702, granted October 26, 1880. If Humphreys had *one* set of change gears arranged in conical form, and Bley had *two*, Riley seems to have been determined to outdo them both by providing *four*, aggregating in all twenty-four gears, by which he could cut fifteen different pitches. He makes this somewhat remarkable statement: "In a planing machine it has been proposed to use two intermeshing series of gear wheels, the wheels of one series running loosely on their spindle, and capable of being individually connected thereto at will." It does not seem that the proposed plan ever came into general use. Another statement in this specification is

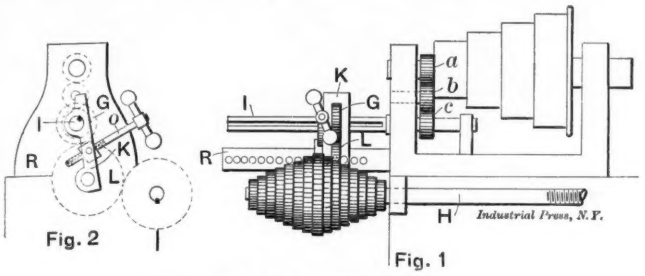


Charles W. Riley. No. 233,702, Oct. 26, 1880.

of more importance. It is this: "I am aware that it is not new to construct a feeding mechanism of two series of intermeshing gear wheels, the wheels of one series fixed to their shaft, and the wheels of the other series revolving loosely upon, but capable of being individually keyed to their shaft." Fig. 1 is a front elevation and Fig. 2 is an end elevation of this device, while Fig. 3 is a longitudinal section of the arrangement for operating the locking keys. In this part of the device the sleeve *v* may be moved in or out so as to bring the key *x* into engagement with any one of the series of gears. When in the proper place the key *x* is forced in or out by the rod *o*, in which is fixed the pin *q*, operating in an inclined slot for that purpose. The sleeve *v* is held in any desired position by means of the sliding arm *H*, traveling upon the square bar *M*, to which it may be fixed by the pin *t*, fitting into one of a series of holes in the bar *M*. The device at *C* is of the same construction and operation. Motion is transmitted from the gear *a*, on the head spindle *A*, through the gear *c*, the cones of gears on shafts *C* and *E* to the gear *e*, thence through the gear *d* to the connecting cones of gears on the shaft *D*, to that on the lead screw *B*. While this device would no doubt accomplish what it was designed for, it seems much too complicated for convenient use or long wearing qualities.

The patent of Andrew Hyde, of Hatfield, Mass., which was granted October 4, 1881, and is numbered 247,764, appears to be in the nature of a combination of the ideas of Humphreys as to the "traveler" with its sliding pinion and that of Miles, with his cone of gears, placed closely in contact with each other. In fact the sliding pinion arrangement is the same

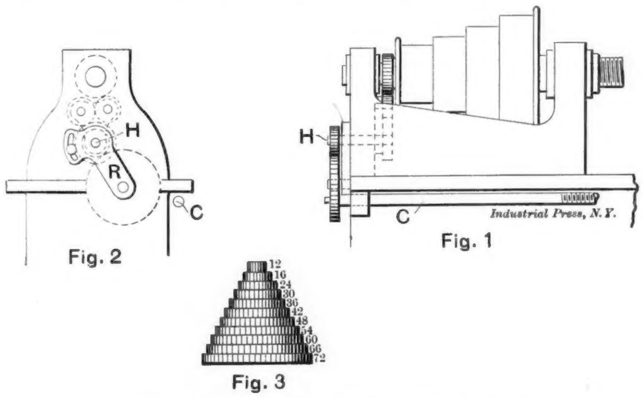
as that adopted by Miles except that his method of locking it is different. The driving is effected through a stud or head shaft connected by gears within the head as some lathes are now constructed. There is nothing really new about it except the method of locking the sliding pinion bracket. His idea of arranging the set of gears in the form of a double cone, with such gears as cut even pitch threads on one end and those which cut odd pitches on the other could hardly be classed as an invention. The result did not mark any distinct step in advance. Fig. 1 is a front elevation and Fig.



Andrew Hyde. No. 247,764, Oct. 4, 1881.

2 is an end elevation of this device. The sliding frame or traveler *K*, carries the gears *G* and *L*, journaled in it, the former splined upon the head shaft *I*. By this means the motion is communicated from the head gears *a*, *b*, *c*, to any one of the gears of the double cone, and held in position by the clamping screw *o*, whose lower end rests in one of the recesses in the bar *R*. One difficulty of this arrangement would be the crowding together of the gears when the lathe was running one way and the strain to force them apart when its motion was reversed. Probably the noise produced by such an arrangement of gears would be anything but pleasant. The long overhang of this double cone of gears would be very objectionable.

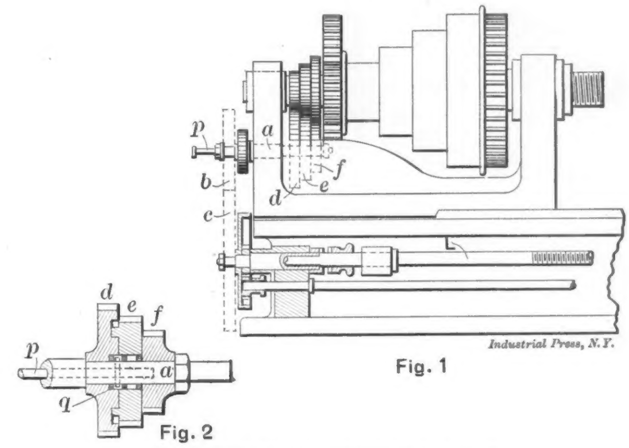
Patent No. 252,760, dated January 24, 1882, and issued to George A. Gray, Jr., of Covington, Ky., relates to the method of arranging the usual change gears, in which the stud plate is pivoted upon the stud or head shaft and carries always the same idle gears. The lead screw having a four-pitch thread and the change gears varying by six teeth each from 12 to 72, and the stud gear having 24 teeth, made a convenient arrangement; and changes were made by removing one



George A. Gray, Jr. No. 252,760, Jan. 24, 1882.

gear only and replacing it by another, the stud plate being adjusted accordingly. This saved the changing of the idle gear, and cut threads from two to twelve per inch. In the drawings, Fig. 1 is a front elevation, and Fig. 2 is an end elevation of the device, while Fig. 3 shows the stack of change gears which were used upon the lead screw *C* only. The arrangement of the stud plate *R*, journaled upon the head shaft and held at any desired point by a clamping bolt, is in the ordinary manner. While the inventor did not avoid taking off a gear and substituting another for each different pitch, it was probably a more satisfactory and practical arrangement than some of the more complicated and pretentious devices, and no doubt served a good and useful purpose.

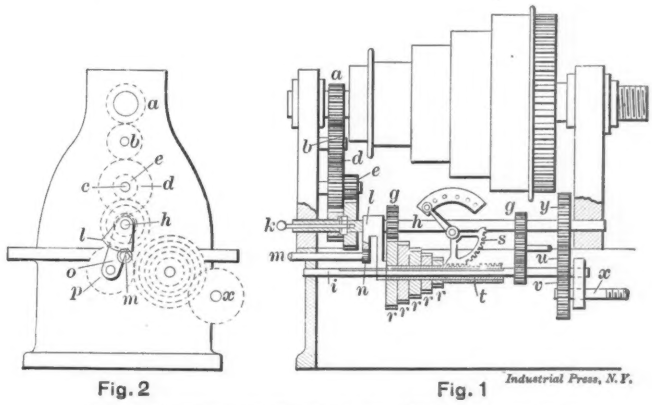
The ear-marks of a practical mechanic are quite visible in Patent No. 462,481, granted November 3, 1891, to Joseph Flather, of Nashua, N. H. In this case instead of one fixed feed gear on the main spindle of the lathe, three or more gears of varying sizes are fixed thereon. On the head shaft or stud are the same number, and of corresponding sizes loosely fitted and adapted to be engaged individually by means of a sliding rod and pin, the stud being made tubular for that purpose. A simple and effective arrangement of driving the feed rod is provided, which does not affect the subject herein discussed. In the drawings, Fig. 1 shows a front elevation of the invention, and Fig. 2 is a longitudinal section through the cone of gears on the head shaft. Upon the head shaft or stud *a* and upon the lower lead screw *L* are fixed and operated, change gears in the usual manner, except that the value of each change gear in screw cutting is multiplied by the number of feed gears on the head spindle. So that while



Joseph Flather. No. 462,481, Nov. 3, 1891.

Riley, for instance, used twenty-four gears to cut fifteen threads, Flather needs but eleven, or less than half the number. The gears *d*, *e*, *f*, on the head shaft are arranged as shown in Fig. 2. The center gear *e*, being of necessity bored entirely through at an enlarged diameter to accommodate the sliding pin device, is held in position concentrically by a projecting ring formed upon it and fitting into a suitable annular recess in the gear *d*. The gear *f* has a clutch member extending into the gear *e*. The operating rod, *p*, carries a pin, *q*, which engages the clutch member of either of the three gears as desired.

On February 2, 1892, Peter and William Shellenback, of Richmond, Ind., were granted Patent No. 468,183. These inventors fix a cone of gears on a sleeve splined and sliding upon a driving shaft located within the bed, and moved to any position desired by a pinion whose teeth engage with a series of grooves turned in a projecting end of the sleeve, forming in effect a rack. This pinion is fixed upon a shaft



Peter and William Shellenback. No. 468,183, Feb. 2, 1892.

projecting out at the front of the head, where it is controlled and held in position by a lever provided with a spring pin adapted to enter any one of the holes in a fixed segment. Journaled upon an intermediate shaft located in the head above the driving shaft are the usual driving pinion and an intermediate pinion journaled on a swinging arm operated and held in position by a shaft and pinion engaging teeth cut on a segmental portion of it. This pinion is fixed upon a shaft which projects outside of the end of the bed, where it is operated and held in position by a lever swinging over a segment

and provided with a spring pin which enters any one of a series of holes in the segment. The peculiarity of this arrangement is that instead of the usual "traveler" with its two pinions for connecting the shaft upon which it slides to any one of the series comprising the cone of gears, the cone of gears itself slides bodily to any one of the required positions. Among other things the inventors say: "In many kinds of work it is desirable that the carriage should move in one direction while the tool is cutting, and when the tool is withdrawn from the work it should return to the starting point to enable the tool to make a fresh cut." Perhaps we ought to be grateful for this information. In the drawings, Fig. 1 is a front elevation, showing the bed and a portion of the head in vertical section, and Fig. 2 is an end elevation. Power for driving the lead screw is transmitted from the head spindle through the gears *a*, *b*, to a fixed stud *c*, having journaled upon it the two gears *d*, *e*, which are fixed to each other and mesh into the gears *f*, *g*, on a supplementary shaft *h*, to which either may be connected by a sliding key operated by the rod *k*. Upon the shaft *h* is fixed the toothed segment *l*, which is operated by the shaft *m*, having the pinion *n* formed upon it. Fixed also to the shaft *h* is the arm *o*, having journaled to a stud fixed in it the connecting gear *p*. This is continually in mesh with the gear *q*, fixed to the shaft *h*, and capable of being brought into engagement with any one of the cone of gears fixed upon a sleeve splined to the shaft *i*, as they are brought opposite to it by the action of the toothed segment *s*, engaging in the grooves of the sleeve *t*, to which the gears *r*, *r*, *r*, *r*, are fixed. Motion is communicated from the shaft *i*, through the gears *u*, and *v*, to the lead screw *x*. Motion may also be communicated by way of the gear *g*, without bringing the cone of gears into use.

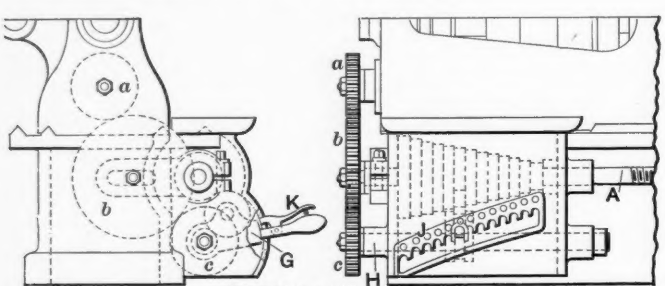


Fig. 2 *Industrial Press, N.Y.* Fig. 1

Wendel P. Norton. No. 470,591, March 8, 1892.

We now come to a patent which has probably caused more interest and discussion on this subject than any one previous to its issue. It is No. 470,591, and was issued March 8, 1892, to Wendel P. Norton, then of Mount Vernon, N. Y., but later of Torrington, Conn. It contains some of the good ideas of the earlier inventors, now brought into good mechanical form and combination for producing practical results. Humphreys in 1868 introduced the cone of gears. They are here. He wrote: "I place my gear wheels all upon a shaft *A*, ranging from the smallest to the largest." Norton says: "On the shaft *A*, and within the box *B*, are secured a series of gear wheels *E*, of varying diameters, arranged step-like," etc. Humphreys placed his gears a little more than the width of the face apart. Norton places his close together, like Miles in 1871 and Hyde in 1881. The clumsy arrangement of Humphreys' "traveler," Miles' "movable swinging arm" and his "shifting clamp," and Hyde's "sliding frame," is replaced by a compact and well-arranged sliding, forked lever, carrying the connecting pinion. Altogether it is a good example of how the crude efforts of early inventors may be, by the present advanced state of mechanical knowledge, put into practical and useful combination. In the drawings, Fig. 1 is a front, and Fig. 2 is an end elevation of this device. Motion is communicated from the head spindle by way of the usual head shaft and the gears *a*, *b*, *c*, to the supplementary shaft *H*, upon which is fitted the sliding arm *G*, the latter carrying a gear splined to the shaft *H*, and also the connecting pinion *F*, journaled in it, and capable of connecting with either of the gears *E*, *E*, *E*, etc., on the shaft *A*. This sliding lever *G*, is conveniently arranged with a handle, and a thumb-lever *K*, having formed upon it a pin entering any one of the holes in a fixed plate *J*, its position first being readily located by a series of notches in the lower edge of the plate into which a portion of the lever *G*, enters. The pin on the lever *K*, finally secures it accurately in place. The device has been for several years in practical use in many shops in this country.

There is nothing especially noticeable in the effort of William Shellenback, of Richmond, Ind., who on April 10, 1894, obtained Patent No. 518,164, for his device, in which he

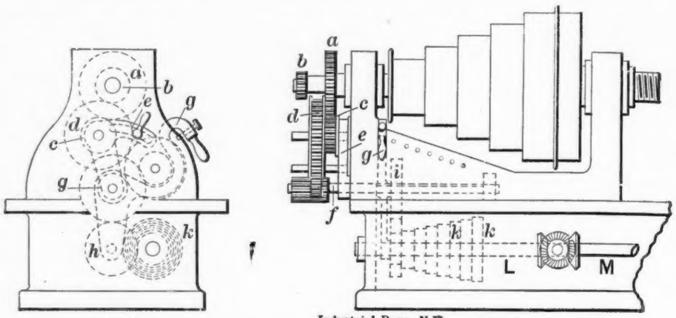


Fig. 2 *Industrial Press, N.Y.* Fig. 1

William Shellenback. No. 518,164, April 10, 1894.

placed a cone of gears on a shaft within the bed and applied the much-used traveling pinion to connect its different gears with the driving shaft above it. In the drawing, Fig. 1 is a side elevation, and Fig. 2 is an end elevation of the device. A yoke plate *e*, carries a stud upon which are journaled the flanged gears *c*, *d*, which may thus be brought into action by sliding them upon the stud, their flanges retaining them in place. By this means a second series of speeds produced by the cone of gears is obtained. The shifting lever *g*, is journaled upon the supplementary shaft *f*, and has journaled upon a stud fixed in its lower end the connecting gear *h*, by which the gear *i*, on the supplementary shaft *f*, is connected at will with any one of the gears *k*, *k*, etc., of the cone of gears splined to the supplementary shaft *L*, which is connected with the lead screw *M*, by a short transverse shaft extending through the front of the bed and operated by miter gears. While the space within the bed affords plenty of room in which to place any number of gears and their necessary appendages, and while they are out of the way more than if placed in front of the bed, the device has the disadvantage of being difficult to get at in case of accident, and until we can do much better in our designs and workmanship, and have a higher grade of operatives to attend them, accidents will sometimes occur to the best constructed machinery.

The second patent of Wendel P. Norton, viz., No. 519,924, granted May 15, 1894, was not properly for change gears, but intimately connected with them inasmuch as it was for a compact and well-devised method of reversing the motion of the change gears by means of three miter gears located within the lathe head and conveniently operated by proper levers

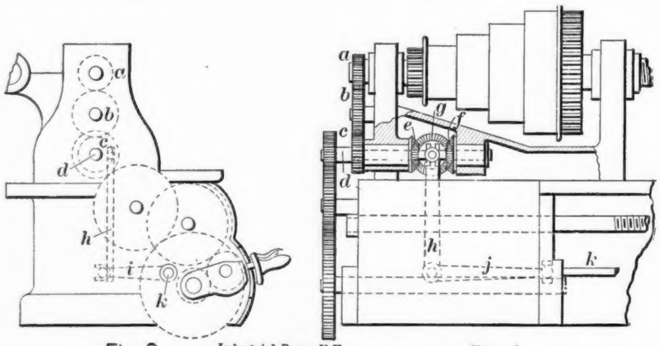


Fig. 2 *Industrial Press, N.Y.* Fig. 1

Wendel P. Norton. No. 519,924, May 15, 1894.

and a reversing rod worked from the lathe apron, thus forming an automatic stop. In the drawings, Fig. 1 is a front, and Fig. 2 an end elevation, a portion of the head being shown in vertical section in Fig. 1 for the purpose of more clearly showing the reversing device. Power to operate the lead screw through the medium of the device shown in his Patent No. 470,591, is transmitted from the head spindle through the gears *a*, *b*, *c*, to the head shaft *d*, which has

loosely journaled upon it the miter gears *e* and *f*. Both of these gears are in mesh with a third miter gear *g*, located in their rear and journaled upon a fixed stud. Between the miter gears *e* and *f*, there is a clutch splined upon the head shaft *a*, Fig. 2, with clutch members formed on each face and adapted to be engaged with similar clutch members formed on either of the miter gears *e* and *f*. This clutch is operated by the levers *h*, *i*, *j*, and the tumbling rod *k*. This device is really a continuation, or rather perhaps the completion of the device shown in the former Norton Patent No. 470,591, so that he accomplishes, not only a great number of changes, but also reverses them at will or automatically.

* * *

RECOLLECTIONS OF AN ENGLISH MACHINE SHOP.

C. VICKERS.

Twenty-five years ago I made my first attempt to learn a trade in the machine shop of one of the largest engineering works in the Eastern counties of England. I was then a boy of 14, and had decided to become a fitter, chiefly because the word "fitter" sounded better to my ears than "turner." Machinists in those days in England—and probably now—were known either as "fitters," "turners," or "erectors," the word "machinist" not being used. A fitter was a vise hand; a turner, a lathe hand, and an erector assembled the different parts and built the machine. So I was provided by my parents with the regulation white overalls and jumper of the machinist, and started to work in the turning gallery.

The turning gallery was a balcony which extended around the walls of the big machine shop at a height of twelve or fifteen feet. This gallery was filled with lathes and other machines, all operated by apprentices. The one I was put at was for the purpose of facing the heads of bolts, and rounding off the ends of studs. It consisted of a cone pulley and a chuck with changeable jaws to accommodate the different diameters of the bolts, etc. The spindle was hollow, about four inches in diameter and cut away on two sides to enable operator to insert his hand and forearm when changing the jaws of the chuck, which were in three segments and were tightened by a nut through which they protruded slightly.

To turn a stud, the jaws were opened by loosening the nut, with a huge spanner, then the stud was pushed in and the spanner shifted onto the hexagonal part of the nut, its long handle resting against the lathe bed—which held it from turning. The power was switched rapidly on and off, and the momentum of the lathe ran the nut up with a jerk, when the spanner was shifted onto the circular part of the chuck, where it rested while the machine was in motion.

There were over a hundred boys working in the gallery, all learning to be turners, fitters, or brass-finishers, and they were promoted at regular intervals, and in their turn. There was an established schedule of wages, based on the boy's age, with a regular annual increase for five years when the boy was "out of his time."

As was natural among so many boys, there was much practical joking when the foreman's back was turned and many a protest reached him from indignant machinists down below, who had been pelted by metal or "soaked" by greasy waste. But it was useless to try to discover the offender, because the greatest crime any boy could commit was to "split" against his fellows. The foreman knew this, but once in a while he would give the boys a lesson. One day, just before the bell rang, some one threw a hammer across the gallery. It missed its object (luckily, perhaps) and struck a gas fixture, breaking it off short. When the foreman saw it he went to the boy nearest the wreck, and asked him if he knew who threw it. "Yes," was the answer, "but I won't tell." As the foreman expected this he said nothing, but just handed him his discharge slip, then passed to the next boy with the same question and got a similar answer, and inside of five minutes there were a half dozen boys stringing out to the timekeeper's office.

Having depopulated that corner of the gallery the foreman desisted from his inquiries, and the real offender escaped, although I have known cases where he nobly came forward and confessed to save his shopmates their jobs. Such a boy was considered a hero, but as he was promptly cut off from the scene of his self-sacrifice his fellows never had an opportunity to show him their appreciation of his conduct. So, as the boy with a conscience got all the bitter with none of the sweet, such conduct was not exactly looked for.

This establishment manufactured "threshing machines," portable and stationary engines, locomotives, pumps, traction engines, and steam dredges or "navvies," as they were called. There were four or five other such firms in that city, each employing from 1,200 to 2,500 men, and the rate of wages, hours of labor, and general shop rules were identical in each. Fifty-four hours constituted a week's work, and over that (up to 64 hours a week) was paid at the rate of time and a quarter; all overtime over 64 hours, time and a half. In times of prosperity these works ran overtime for years at a stretch and when adversity came, the hours were shortened and the men paid accordingly.

Work was commenced in the morning at six o'clock and continued until eight, when a half hour ("breakfast time") was given; dinner hour was from 12:30 to 1:30 P. M., quitting at five o'clock, for four days—one day having ten, and Saturday six hours. Each man on entering the company's employ was furnished with three brass checks, with a number stamped thereon. The works were opened in the morning at fifteen minutes to six, and the employes had to file through a corridor, on one side of which was a long window, behind which sat the timekeepers. The window sill, a narrow ledge, was just high enough for a man of ordinary size to rest his elbow on; it was brass covered, and a slot ran longitudinally from end to end. This slot was just wide enough to admit a check, and as the men passed on, they slid their hands along the sill and dropped in their check, and the action after awhile became mechanical so that it was rare that anyone forgot to register.

At the stroke of six the slot was closed, and all who missed putting in their checks had to lose a quarter of an hour. They were given another chance to get in from 6:10 to 6:15 A. M., after which they were "half-houred," the slot being again open from 6:20 to 6:30.

Then it closed until breakfast time, being open from 8:20 to 8:30. The same chance was given the tardy ones to record their time on the quarter or half hour, both at breakfast time and noon. Thus by noon, the three checks were all in, and before 5 o'clock the check boy came around and again distributed the checks. Every man had to leave the works at meal times, large, comfortable mess rooms being provided for them outside of the works. There were generally two of these rooms—one for smokers, the other for non-smokers. They were furnished with rows of long, heavy, well-scrubbed pine tables, with benches on either side, the men sitting in rows facing each other, every one having a recognized seat.

There were also large ovens for warming the food, and regular attendants paid by the firm, called mess men, attended to this and the other duties of scrubbing, etc.

Tea was the beverage most in favor, and was carried to work by the men, in tin pails and bottles, on which was an identifying tag. They were left in the mess room in the morning, and by breakfast time their contents had been heated and the cans were placed on the first table, past which the men filed and picked out their property.

The Saturday half holiday was religiously observed the year round, no matter how busy the firm might be; work ceased for the week on Saturday noon. Saturday was also pay day, and the paying of 2,000 men in cash occupied less than a half hour. The timekeeper's office had several windows, opening into the yard. At each open window would be stationed two timekeepers, one of whom held a record of the names from which he would read off as the men filed past. After the name was called, the other timekeeper would give the number and as he did so, pass the money—which was inclosed in a small canvas bag, with the number printed thereon—to the workman, who, as he reached for his pay, repeated his number. When anyone missed his turn, he had to wait until the last, when such were called over again. The empty bags were generally returned, as the men passed through the gates, being tossed into a receptacle there for the purpose, although it was allowable to retain them until the following Wednesday. Each department was paid as a whole, the numbers running consecutively.

But my ambition to become a "fitter" was doomed to disappointment. One fatal day, some one ate an orange and used the peel, with the aid of a piece of rubber, to annoy the much-tried workers below. "Tubby," as the portly manager was facetiously known among the men, happening past, saw the effect but not who caused it; he promptly ascended the gallery, and hotly interviewed the foreman, who got revenge for his "calling down" by depopulating that portion of the gallery from which the missiles were supposed to have come. This time I was in it, and went forth from that shop, as others had done, and eventually entered another. But this time it was a foundry, and so it came to pass that the world became afflicted with another molder.

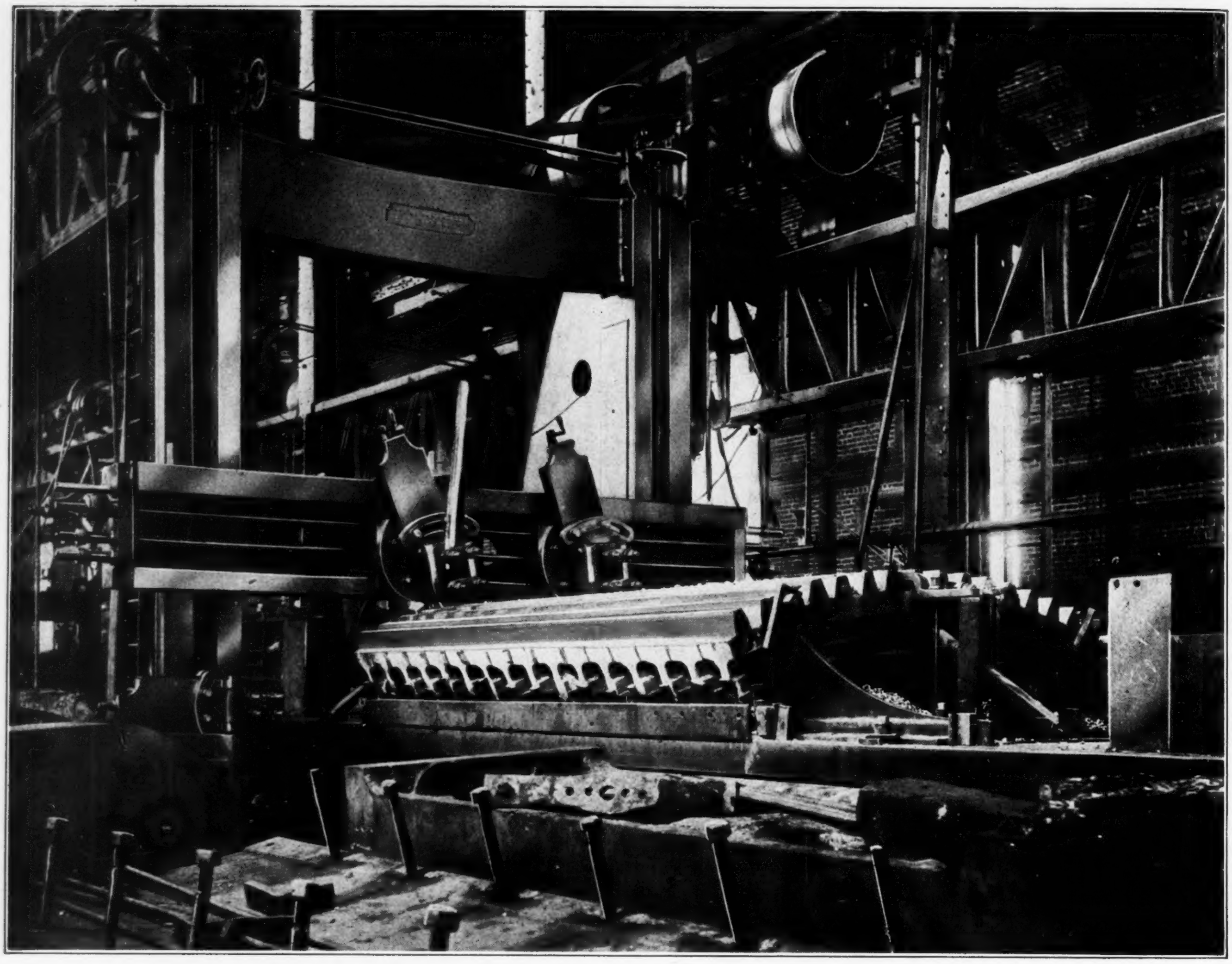


Fig. 1. Planing Gear Teeth in sixteen Segments of a 20 ft. 9.55 in. Diameter Steel Gear Wheel for Ashley Plane, C. R.R. of N. J.

GEAR CUTTING EXTRAORDINARY—A HUGE DRILL PRESS JOB.

While it is by no means a rare job to machine rack teeth on a planer, or even to cut small spur gears in this way, we think that the gear job shown in Fig. 1 is a somewhat unusual one both in the matter of size and in the manner in which it was done. Particularly the latter, since the cutting of spur gear teeth on a planer is ordinarily a tedious and troublesome job unless special fixtures are employed, but in this case, although it was done without special appliances of any kind, the process was one that should compare most favorably in cost with any other that has been devised, and it certainly appears to be the most feasible one to follow in a shop not specially equipped for heavy gear cutting. Especially does this apply when the gear is composed of two sets of segments, arranged side by side, which were so designed that the total number of teeth in one set is an exact multiple of the number in one segment. This made it possible to plane the whole number of segments at one setting.

The gear in question is one being built by the Bethlehem Steel Co. at South Bethlehem, Pa., for the Ashley plane of Central Railroad of N. J. The rim is composed of 16 cast steel segments arranged side and side in two sets of 8 each. The segments are each 8 feet 2 inches long on the pitch circle and contain 16 teeth of 6⅛-inch pitch, making 128 teeth in the circumference. The pitch diameter is 20 feet 9.55 inches; the face width of a segment, 9¼ inches; total width of rim, 3 feet 7½ inches; width of hub, 5 feet 6 inches; diameter of hub, 4 feet 4 inches; total weight of 16 segments shown on planer, 40,960 pounds.

In Fig. 2 is shown the upper half of a cast steel head of a 12,000 ton forging press being built for the Carnegie Steel Co. branch of United States Steel Corporation. This huge casting which is estimated to weigh 250,000 pounds, had been planed at the time the photograph was taken, this operation having been performed on a large pit planer of the type used for planing armor plates. The work does not reciprocate on these machines, the crossrail and heads traveling instead on horizontal ways between which the work is placed in a deep pit. The illustration shows the casting in front of a Bement, Miles & Co. special double drilling and boring machine. This machine has two columns which carry between them a horizontal arm on which are mounted the spindle heads. The horizontal arm may be rotated so as to present the spindles in any desired direction in parallel planes. The spindles can be presented to any part of a vertical plane 17 x 20 feet. In the illustration the work being done is boring out the large bolt holes, one boring bar and the temporary housing supporting the outer end showing at the further side and upper corner.

The dimensions of the steel casting are: Length, 24 feet 4 inches; height, 13 feet 2¼ inches; width, 5 feet 2 inches. A special car has been built to transport the parts of the forging press to Pittsburg. In connection it may be mentioned that the Bethlehem Steel Co. have in their own plant a still larger forging press in the matter of capacity, having the power to exert a pressure of 14,000 tons. The

press and 15,000 horse power pumping engine used to operate it were illustrated and described in the October, 1899, issue of MACHINERY.

* * *

NOTES ON FORCED BLAST HEATING SYSTEMS.

At a recent meeting of the New York Railroad Club an interesting discussion took place upon the subject of heating railroad shops and other one-story buildings of the same na-commonly used at the present time in plants of all descriptions.

The distribution of the air by means of pipes should be so carried out that the lower part of the room is kept at a comfortable temperature, while at the same time no disagreeable drafts are produced. It has been found that by properly proportioning and directing the delivery flues most satisfactory results can be secured. Illustrating this point some very interesting examples were cited, at the meeting, by Mr. C. H. Gifford, of the B. F. Sturtevant Co. He said:

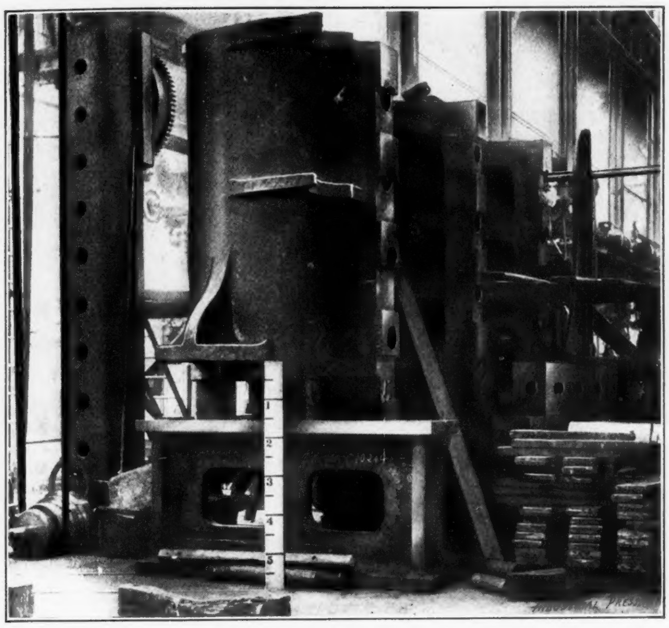


Fig. 2. Boring Bolt Holes in 250,000 pound Steel Casting for Carnegie Armor Plate Press. (See opposite page.)

"In the first place, if you desire air or almost any other form of gas or substance at any particular place at any particular time, the best way is to provide a suitable conduit to deliver it there, and I would add, if there is any difficulty, which there may be, by air blowing on an individual workman, it is a simple mechanical detail to rectify it. If you are unable to predetermine where the men or machines are to be located in a building, you can simply have an adjustable discharge opening from the pipe delivering the air and if, perchance, it blows upon some one, there generally is some space near the person to which the air can be directed and therefore cause no inconvenience whatever.

"As an example of what can be accomplished by distribution, I have in mind a machine shop, that of the New York Shipbuilding Co., which as a machine shop is not dissimilar to one designed for railroad work. They have a building which I believe is about 1,100 feet long, about 250 feet wide and 82 feet high. The proposition was to heat one-half of this building and leave the balance of it unheated. It was a problem that came to me, and I must say that I was a little phased at attempting to heat one end and not have any interference from the other end. We however conceived the idea that there could be a partition put across the middle of the building about 12 feet high. We could then bring the heated air down to the zone which it was desired to heat, which was not over 8 feet above the floor, and in that way we could perhaps confine the air in the space, so as not to have much effect on the rest of the building. It was something of a speculation and rather a bold attempt, when you consider entering into a guarantee which might involve a serious loss; nevertheless it was done.

"The apparatus is arranged under the landing platforms of the gallery which surrounds the shop, so that it is out of the way of the cranes. Pipes are carried along beneath the runway of the cranes and branches are brought down on the posts and discharge the air toward the floor, the outlet being in the form of a Y, which is adjustable.

"We were very much gratified after the plant was started to find that it performed just as was expected it would, and it is surprising to note the difference in temperature between the two sides of that partition; it is almost the same as when you pass from the building out of doors. The result is simply due to the fact that the air was brought down and continually pressed down into the space which it was desired to heat."

Further emphasizing the advantages of correct distribution Mr. Gifford says that it is "possible in some cases to introduce $50 worth of additional pipe to carry the air where it is most needed, so that you can, on account of this, leave out $100 worth of heating apparatus. That is, you can get equal results by using smaller apparatus and less steam."

The adoption of the fan system renders the control of the heating apparatus and of the ventilation ideal. During very cold weather, or in the morning when the building is being heated up, the air supply may be drawn from within the building itself, thus effecting a great economy of heat. In some buildings having a very high cubic space per occupant, sufficient ventilation during the winter time will be supplied by the leakage of air through doors and crevices about the windows by transfusion, etc.

"The pipes for a heating system should be so arranged that the air will not be discharged directly upon the workmen; it is also true that hot air will do the most good if it is put where it is needed. If the space around the walls of a building is properly heated, one may never worry about the center, as that will keep warm.

"We have found, therefore, that most satisfactory heating will result from numerous pipes discharging on the outside walls at a point about 6 feet to 8 feet above, and directed toward the floor. These pipes should be located from 25 feet to 40 feet apart, depending upon the character of the building. This arrangement causes hot air to be blown downward, whence it spreads on the floor, keeping it warm before the air has a chance to follow its natural tendency and ascend to the roof. Hot air has a very bad faculty of getting up in the trusses and if you blow the air directly at the floor and get the floor warm, at the same time keeping the outside of the building warm, your problem is practically solved. In the case of an underground duct, it is well to use short outlet pieces which will discharge along the walls at the floor.

"At the works of the Fore River Ship and Engine Building Co. they have an overhead pipe system with drops on the walls, which was put in according to the regular practice. Later they added 50 per cent. to the building and are now heating it with the same apparatus. That is, we picked out a fan heater which we considered to be the proper size for that particular building and it worked in a perfectly satisfactory manner. Later the ship company added 50 per cent. to the length of the building. We extended the piping and carried drops on the walls every 30 feet, blew the air on the floor with ample outlets on the ends, and in the coldest weather the heat of the building, which is 50 per cent. larger than we would care to guarantee with our apparatus, was perfectly satisfactory to them. Their success is entirely attributed to the excellent system of air distribution.

"At the shops of the Atchison, Topeka & Santa Fe Railway Company, the underground system was adopted and low horizontal outlets were provided which distribute the air at the floor and along the walls. This is an extremely large shop, the contents being about four or five million cubic feet. The shop is heated by four large apparatuses and the underground ducts extend almost entirely around the building. The pipes are not over three feet high, the air being discharged horizontally along the floor, and I understand that the building is very satisfactorily heated.

* * *

Water in freezing, is said to exert an expansive force of about 30,000 pounds per square inch. No wonder that pipes burst!

NEW SHOPS OF THE AMERICAN TURRET LATHE MFG. CO.

The buildings of the new plant of the American Turret Lathe Mfg. Co., Warren, Pa., embody a number of features of more than ordinary interest in shop construction. The view in Fig. 1 shows the plant when nearly completed. The building at the right is the erecting shop and the buildings at the left are for machine work, those in the foreground having a higher roof than those in the background. The power plant is in the small building at the center and a raised passage way, clearly shown in the photograph, is located between the erecting and machine shops to afford room for the large overhead pipes of the heating system, without having to utilize any of the head room of the main buildings for this purpose. It will be noted that all the buildings are of the saw-tooth roof construction.

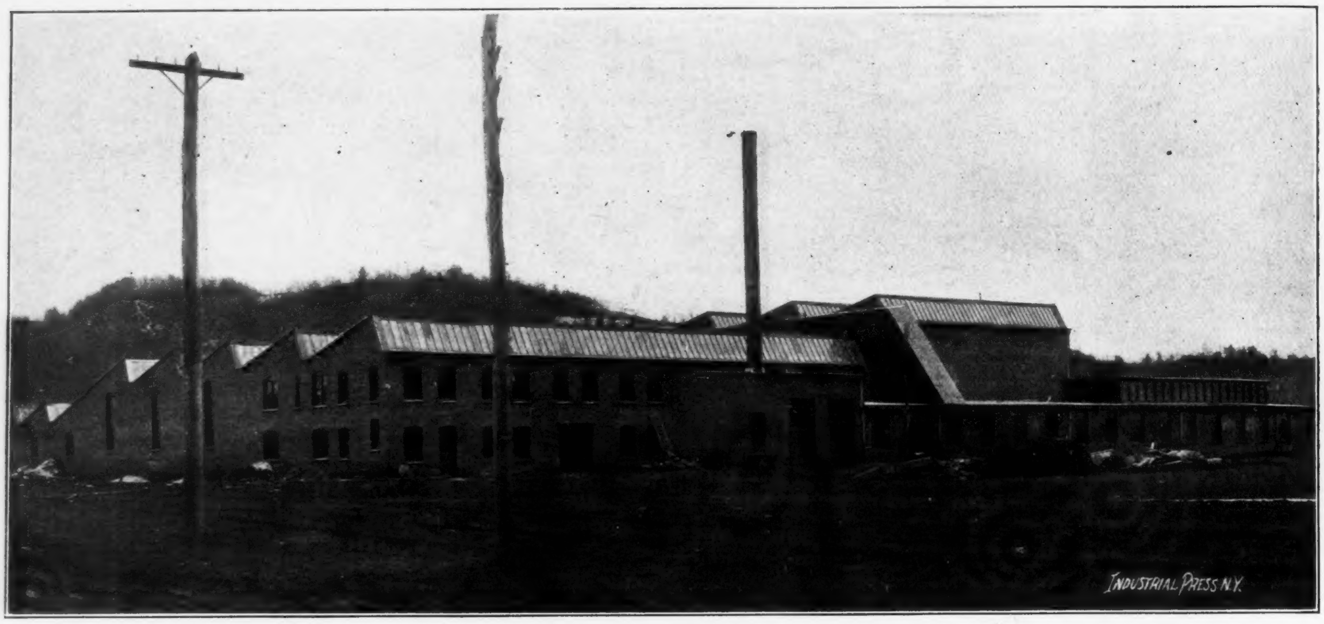


Fig. 1. American Turret Lathe Shops—Note that Saw-tooth Roof Construction is used and that the Buildings are of three different Heights to accommodate different Classes of Work.

In laying out this plant the following considerations were given prominence: First, arranging it in such a way as to permit of a systematic increase without disarranging the original plan of operation. Second, to so design it that the whole floor area should be well lighted and that future additions would not interfere with the light of any part. Third, complete crane facilities, not only in the erecting shop but in the machine shop, wherever required. Fourth, a systematic arrangement of the tools according to the work to be done. Fifth, an electric power transmission along original lines.

With regard to the first of these it will be seen that the buildings may be extended in either direction, maintaining, if desired, the relative proportions between the different departments. To obtain the second condition the saw-tooth form of roof was adopted but an entirely original method of constructing the roof was used, in order to obtain unobstructed room for the numerous cranes that it was desired to install.

Inasmuch as a saw-tooth roof is virtually a flat roof and is built up of short sections, a shop of this construction generally has a great many columns, which interfere with the operation of traveling cranes. Two of the earliest shops of this type were those of the De Laval Cream Separator Co., at Poughkeepsie, N. Y., and the Straight Line Engine Works, at Syracuse, N. Y. The former is used solely for the manufacture of small machine parts, and while it is very well adapted to this purpose it would hardly serve as a model for a concern manufacturing medium and heavy machinery. At the works of the American Turret Lathe Mfg. Co. the majority of the machines built weigh less than 5,000 pounds each, but a considerable number weigh from 10,000 to 20,000 pounds, and an occasional machine weighs much more. This shows the need of the crane facilities.

In the case of the Straight Line Engine Works the spacing between the columns is only 8 feet, while in the erecting shop, where there is a traveling crane, a different type of roof is adopted which allows a free runway for the crane. One of the latest examples of the saw-tooth roof is the fine plant of the De Laval Engine Co., at Trenton, N. J., but this again is of composite design like the Straight Line shops and no provision is made for traveling cranes in the saw-tooth section.

This difficulty is obviated in the shop under description by using a form of truss or girder construction for the support of the roof, which makes it possible to place the columns at a much greater distance one from the other, and gives ample room for the traveling cranes in the machine shop sections.

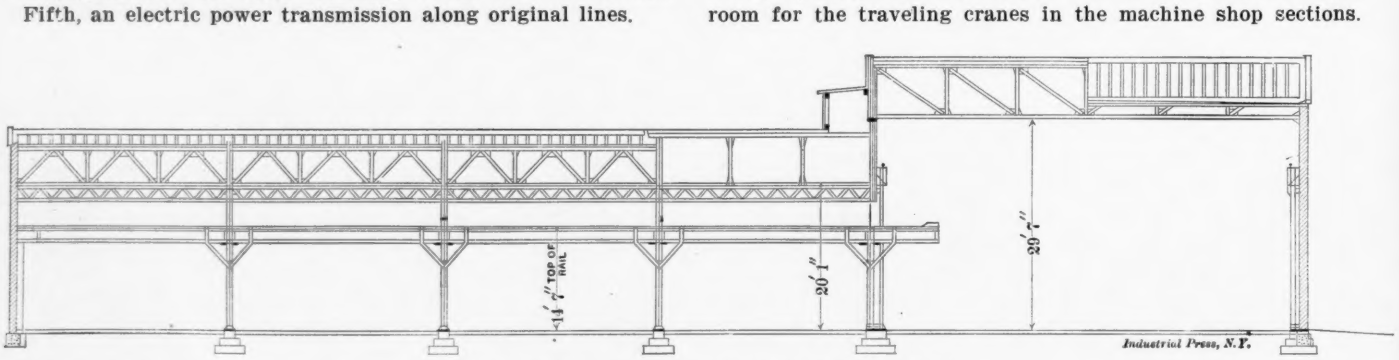


Fig. 2. Showing Girder Construction for Supporting Roof.

By this plan it is not necessary to have any machine tools at all on the erecting floor, which is thus left free for the erection of machinery, without interference from any of the other departments. The runways for the machine shop cranes are at right angles to the tracks of the traveling crane in the erecting shop. In order to transfer the machine parts and castings from the machine shop cranes to the crane in the erecting shop the latter is placed higher than the former and the ends of the tracks of the shop cranes extend into the

erecting shop. This allows the crane carrying a piece from the machine shop to deposit it under one end of the crane of the erecting shop, where it may be picked up and transferred to any part of the floor or to any of the other shop cranes.

business warrants the purchase of a second crane for the machine shop section.

The cross-sectional view in Fig. 2 shows the arrangements of the tracks very clearly and also the girder construction,

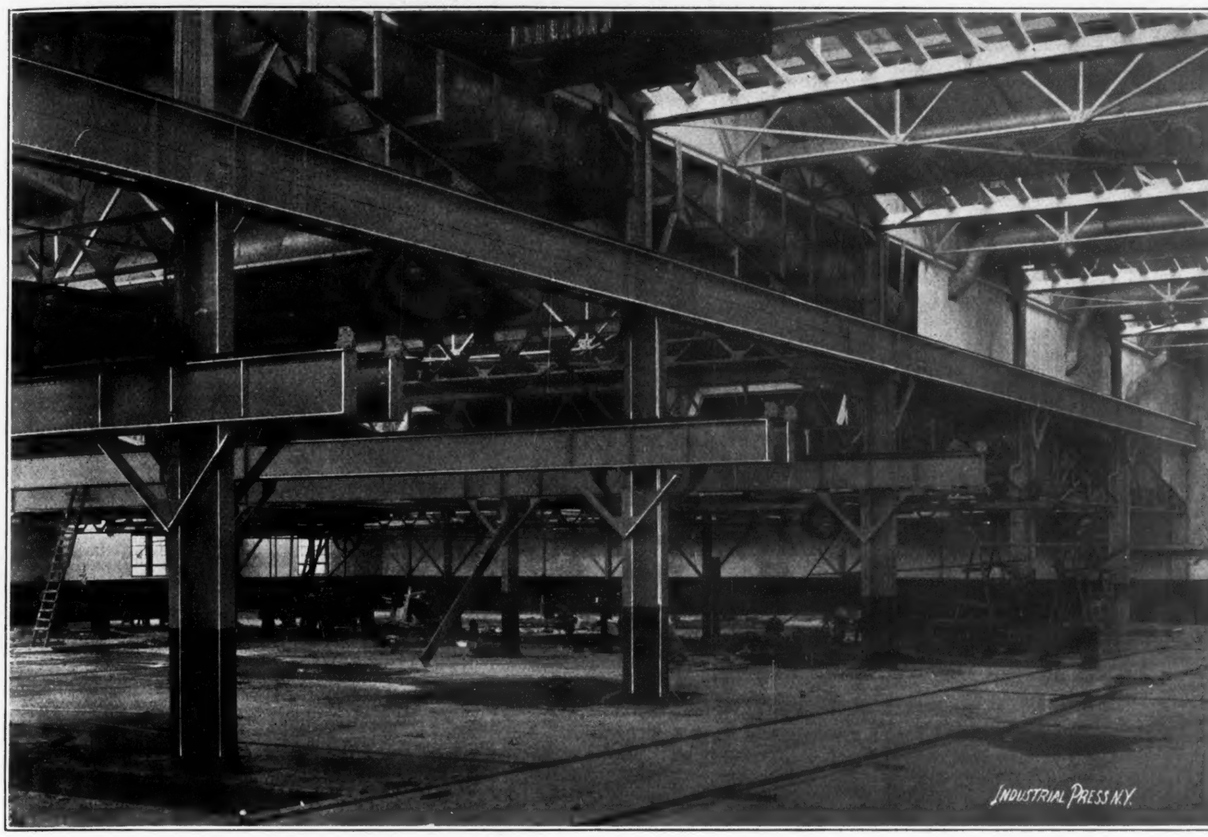


Fig. 3. View of High and Low Sections of Machine Shop, taken from Erecting Shop—Note the Arrangement of Heating Duct and the Extension of Shop Crane Tracks into the Erecting Shop.

It also enables one small crane to be used temporarily on either three of the two machine shop crane runways, since it quite feasible for the erecting shop crane to pick up the small crane and to transfer it from one track to the parallel track. This expedient probably will be resorted to, until the volume of which allows the roof to have wide spans between the columns. The building at the right is the erecting shop shown in cross-section; that at the left, the machine shop shown in longitudinal section. The arrangement of the girders which support the roof will be understood by referring to Fig. 2 and also to

Fig. 4. Erecting Shop with Saw-tooth Roof—Machine Shop at the Right—Car Track enters at the Farther End.

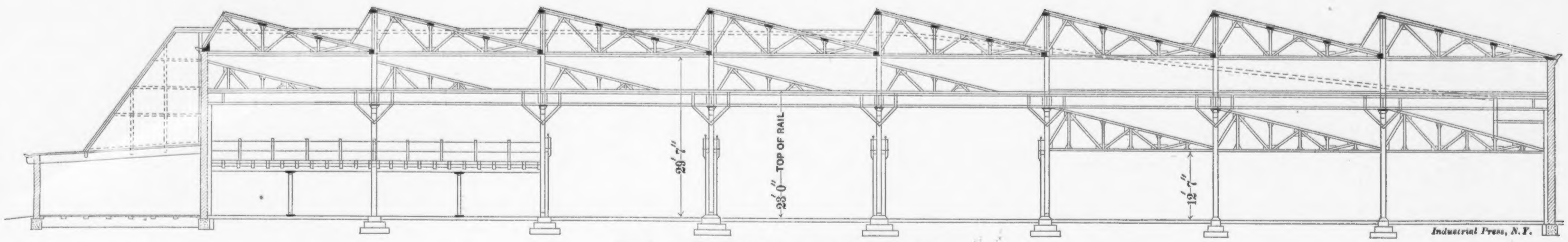


Fig. 5. Longitudinal Section through Erecting Shop.

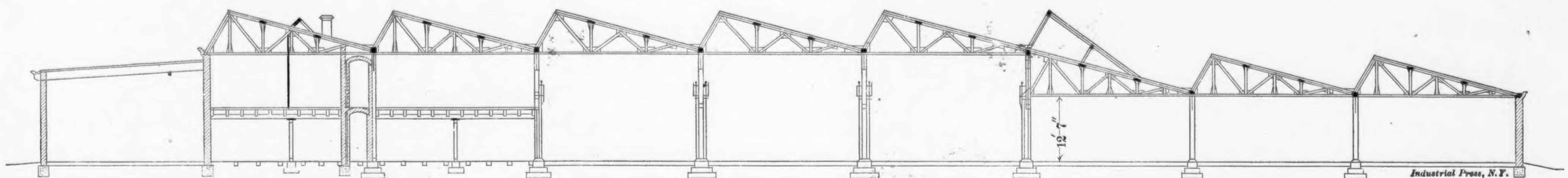


Fig. 6. Cross-section through Machine Shops.

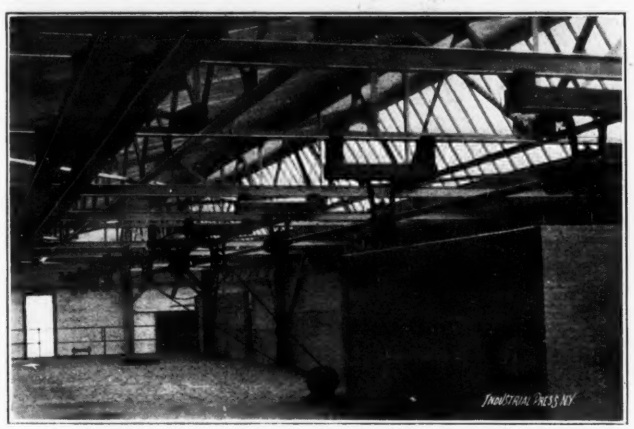


Fig. 7. Method of Supporting Shafting Hangers.

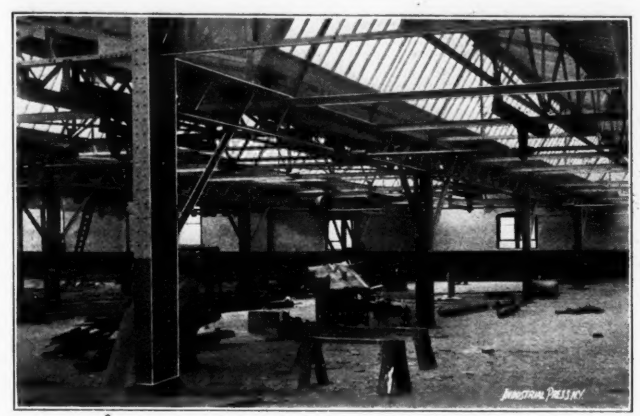


Fig. 8. Low Section of Shop with Overhead Shafting.

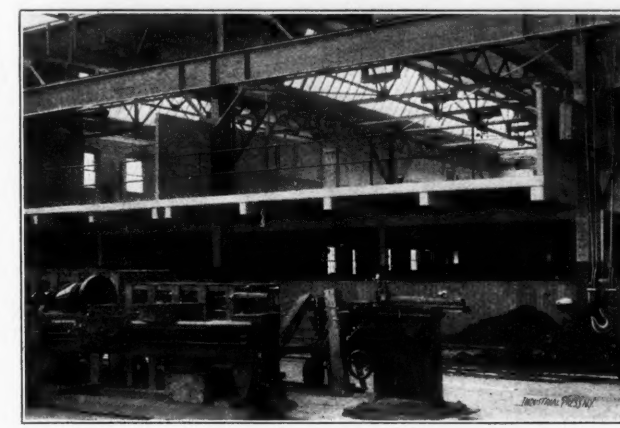


Fig. 9. Section, with Balcony, for Storage, etc.

the half-tone reproductions of the several photographs, which show the interior roof construction.

Fig. 4 is a general view of the erecting shop, which has one of the best-lighted floor areas to be found anywhere. This view shows the relative positions of the traveling crane which serves this department and the crane tracks extended in the form of cantilever beams from the machine departments at the right. Along the west wall and a portion of the east wall of the erecting shop will be arranged a series of jib cranes having a capacity of one ton each. These cranes will give each erector means for handling the small parts without waiting for the main crane.

At the further end of the erecting floor a spur track runs into the shop in a crosswise direction so as to take as little floor room as possible. In this same view, Fig. 4, may be seen, on the upper right-hand side, a duct, previously spoken of, in which the main heating pipe is located.

Further details of the roof construction appear in the two views on this page, where the upper illustration is a longitudinal section through the erecting shop at right angles to the machine shops and looking toward the machine shops. The

upper trusses belong to the roof of the erecting shop, and the lower trusses at the left indicate the relative position of the roof for the high section of the machine shop; while the still lower trusses at the right indicate the low section of the machine shop. The heating duct passing up from the engine room appears at the extreme left, and adjacent to it are a gallery and store room. In the lower view on the last page is a section through the various machine shops taken at right angles to the latter and parallel with the erecting shop. These views in connection with Fig. 1 give a clear conception of the roof construction.

Another important feature of the plant is the construction of the machine shop part of the buildings with roofs of two different heights. The low machine shop is adapted for the lighter tools—such as milling machines, drill presses, grinding machines, screw machines, turret lathes, engine lathes and any light tools that do not require crane service. The higher portion of the shop consists of that part served by cranes, where large tools are placed. The erecting shop is necessarily higher than either of the machine shop sections, both for convenience in erecting machinery and in transferring the parts from the machine shop cranes. The buildings are thus of three heights, which makes an economical construction inasmuch as no money was expended for buildings higher than actually required for the work to be done. It also facilitated an economical arrangement of shop driving, as in the low section where no cranes are required the group system of driving can be employed with line shafts. In the high sections of the shop, where there are the larger tools, individual motors are employed, which is desirable for the convenient operation of tools of this class and which also gives clear space for the cranes. Constant-speed motors are used throughout, with a new variable speed device recently brought out by this company. The motors are all to be placed overhead, although in Fig. 7 one is shown located temporarily on the floor. The method of supporting the shaft hangers is indicated in this view. Cast-iron clamps are provided, by means of which stringers are bolted either to the lower member of one of the roof trusses or else to an I-beam suitably located for the purpose. These parts are all made interchangeable and may be shifted about as necessary. Inasmuch as the line shafts will be motor-driven they can be located with reference to the work without the use of angle joints or quarter turn belts. Thus in the automatic screw machine department the shafting is slightly at an angle so that the screw machines may be set to lap by one another, allowing stock to extend through the spindles in the usual manner.

In laying out the shop, arrangements were made to divide it into departments, of which are: First, the planer department; second, the drilling and boring machines; third, the milling and gear-cutting machines; fourth, the engine lathes and grinding machines; fifth, turret lathes and screw machines. The arrangement of the high and low sections of the shop, as previously explained, is such that where these departments run parallel with the erecting shop they may include part of both the high and low sections—an arrangement that would be desirable where there are both large and small tools in one department. The larger tools could then be served by a crane while the smaller tools, not needing a crane, would be placed in the low section of the shop but still be adjoining the larger tools of the same department. In the case of the planer department, where all or nearly all of the machines need the service of a crane, the department runs at right angles to the erecting shop and does not include any of the low section of the machine shop. It will be evident that a great variety of arrangements is thus possible and that, inasmuch as the different parts of the building are adapted to the various tools so far as height is concerned, the initial cost of the buildings must necessarily be a minimum.

The foundations of the plant are of concrete, the walls are brick and the frame work of steel. The roof planking is of 3-inch yellow pine and the skylights of heavy ribbed glass set in metallic sashes. The floor is of concrete. The building covers about 60,000 square feet of floor space, there are 12,000 feet of crane runway, ¾ of a mile of sewers and the expense of construction is distributed as follows:

Steel work per square foot	33.7 cents.
Concrete floor—6-inches	11.5 cents.
Foundations and brick work	10.3 cents.
Lumber	14.0 cents.
Painting	1.1 cents.
Roof covering	1.1 cents.
Sewers	2.0 cents.
Miscellaneous	6.5 cents.
Total cost per square foot	80.2 cents.

This figure is very low and was obtained only by adopting this economical design and using great care in letting the contracts.

* * *

EUROPEAN ENGINEERING WORKS.

The last annual address of the Engineering Association of the South, with headquarters at Nashville, Tenn., was given by W. H. Schuerman, president of the association. He took as his topic a description of some of the important European engineering works visited during a tour of the continent and in what follows will be found an abstract of his paper, attention being given mainly to parts of the paper that bear upon the branches of engineering in which readers of MACHINERY are most interested.

The European freight car is small compared to the American car. The only advantage it can claim is the greater facility with which a single car can be handled by man power, and at nearly all stations a car can be moved from one track to another by means of turntables instead of by switches; but only one car at a time can be handled. The difference in style of passenger coaches is so well known that it is unnecessary to describe it. It may, however, be worth mentioning that the American plan of having entrances at the ends, with a passage through the car and sometimes through the whole train, is coming into use, especially in Switzerland. The passage is, however, nearly always on the side instead of down the center of the car. The fares on ordinary trains in the different European countries are: First-class, 3 1-3 cents per mile; second-class, from 2¼ to 2¾ cents per mile; third-class, from 1¼ to 1 2-3 cents per mile; fourth-class (in Germany, where fourth-class carriages are run), 9-10 of a cent per mile. Nearly all American tourists travel second-class, but third-class in Switzerland and Germany is not objectionable, and traveling third-class in these countries is an excellent way for one, whose funds are limited, to economize.

European locomotives have neither cowcatchers nor bells. To American ears the whistles on Italian locomotives sound like toy affairs. Hand bells are sometimes used in stations to warn people on platforms of the approach of trains; and at one place where some switching was being done the writer saw a man who, to warn people of the approach of the switched car, was running ahead of it and ringing a hand bell about the size of the dinner bell seen and heard at railroad dining rooms and country hotels in the United States.

Switzerland has a large number of incline railways on which adhesion is not sufficient for traction and a rack is made use of instead. These began to come into use shortly after the completion of the Mount Washington railway in the United States in 1869, largely through the efforts of a Swiss inventor by the name of Riggenbach. He had been working on the problem for many years, but some of the professors at the Swiss Polytechnic school had characterized his proposed construction as a monstrosity. John Hitz, the Swiss consul-general to the United States, returned to Switzerland in 1867 and gave a detailed report to the Swiss Federal Parliament of the Mount Washington railway, then being constructed, which greatly encouraged Riggenbach and facilitated the formation of a company. A road up the Rigi was begun shortly after and this was so successful that several others were built by Riggenbach in different parts of Europe.

The next advance after Riggenbach in the construction of rack railways was made by Roman Abt, a pupil and fellow-worker of Riggenbach, the first of whose roads was built in the Hartz mountains. Up to this time the rack rail had always been anchored below the locomotive in which position it would be in compression. Abt conceived the idea of placing it above the wheels, where it would be in tension, and he made his rack rails of flat bars. As now constructed there are two

or three racks close together, the teeth of one rack being a third or a half their pitch ahead of the teeth of the adjacent one and there are two or three cogwheels working in the racks. The result is that the locomotive climbs the grade very quietly and smoothly.

Another form of rack railway is that ascending Mount Pilatus. The grades that were found to be necessary were steeper than any hitherto used on rack railways. The average grade is 366 feet per 1,000 feet, the maximum being 480 feet. The maximum grade on the Mount Washington line was 33 feet per 100 feet; that up the Rigi, 25 feet per 100 feet. None of the forms of rack rails in use were considered sufficiently safe for this line, and a new form was devised. Instead of being vertical, the rack is horizontal—or, rather, parallel to the roadbed. The center plate has teeth on both sides, and there are two pairs of cogwheels on the locomotive which gear into the racks. Two trains are operated on this line, which pass each other half way up. Except at the passing point, there is but one track. On account of the form of rack rail and position of cogwheels, the ordinary form of switch could not be used. In place of switches there are two traveling carriages, movable by hand—one above and the other below the passing station. Each carriage carries two connecting tracks, which enables either one of the two tracks at the passing station to be connected to the single track above or below.

The subject of Alpine railway engineering naturally brings to mind the great railway tunnels between Switzerland and Italy. These are more interesting to an engineer during construction than after completion. The Simplon tunnel will be about 11 miles long, and, when completed, will be the longest tunnel in the world. The installation at Brigue consists of the necessary offices, workshops, engine sheds, power houses, smithies, and the numerous buildings required for carrying on such an important engineering undertaking. Great care is taken that the miners and men working in the tunnels shall not suffer by the sudden change from the high temperature of the headings to that of the cool air outside. For this purpose a large building has been erected, in which they can take off their damp working clothes; have a hot and cold bath; put on a warm, dry suit; and obtain refreshments at a moderate cost, before returning to their homes. Instead of each man's having a locker in which to store his clothes, a perfect forest of cords hangs down from the ceiling 25 feet above the floor level, each cord passing over its own pulleys and down the wall to a numbered belaying pin. Each cord supports three hooks and a soap dish, which, when loaded with their owner's property, are hauled up to the ceiling out of the way. There are 2,000 of these cords, spaced 1 foot 6 inches apart, one to each man.

The hydraulic power plants to be found in Switzerland are of as great engineering importance as the rack railways and of much more importance from a commercial standpoint. The city of Geneva constructed a water supply and water power plant in the years 1883 to 1888. The Rhone, at the outlet of the Lake of Geneva, is divided into two branches by an island. The island was extended by a wall, and the left branch of the Rhone thereby made into a canal, closed at its lower end by a large L-shaped power house. In the right branch of the Rhone was built a rolling shutter dam, by means of which the water from the lake, or as much as is desired, can be sent through the left branch to the turbines in the power house. About 4,000 horse power is obtained in this way. There are 20 Jouval reaction turbines of 210 horse power, each operating two pumps. Between 8,000,000 and 13,000,000 gallons of lake water are delivered per day for industrial and public purposes, in addition to 2,800,000 gallons for domestic supply. In the years 1893 to 1899 a second plant was constructed lower down on the Rhone. Many other interesting examples of power plants, made possible by the mountainous formation of Switzerland could be mentioned, but of greater interest still are some of the hydraulic distribution plants to be found at different points on the continent and in Great Britain. London has by far the largest hydraulic power supply plant in the world. There are over 130 miles of hydraulic mains laid in London at present. Powerful pumping engines at seven different stations keep them charged at a pressure of from 700 to 750 pounds per square inch. Another pumping station is now nearing completion. The reservoir of power consists of capacious accumulators loaded to a pressure of 750 pounds per square inch, thus producing the same pressure as a standpipe 1,700 feet high. The power is available, day and night and on Sundays, all the year round at a pressure of 700 pounds per square inch—a pressure which enables small machines to perform a large amount of work with a very small quantity of water. The number of consumers is constantly increasing. The number of gallons pumped per week increased from 1,271,000 in 1886 to 14,812,000 in 1902; the number of machines increased from 364 in 1886 to 4,677 in 1902.

In every town where hydraulic power has been established it has succeeded, both mechanically and financially, notwithstanding the competition of all other forms of power generation and distribution. The experience in Manchester is particularly striking. The supply of electricity, of hydraulic power, and of gas are all in the hands of the corporation. The two former were started at the same time, in 1894.

Other hydraulic works of interest are the numerous locks and dams on ship canals, especially in France and Germany; but all that the writer had time to visit was the ship elevator on the Dortmund-Ems Canal near Henrichenburg. It raises vessels of 600 tons in 12½ minutes through a height of 52½ feet at a single operation. The elevator consists of a tank supported on five huge hollow cylinders, floating in deep wells, 30 feet in diameter, 46 feet from center to center, and going to a depth of 97 feet below ground level. The cylinders balance the whole weight of the tank and its contents. Massive screws regulate the motion, and these screws are constructed to sustain the entire weight of the structure in case of failure in any part. The elevator was selected in preference to the construction of a series of four costly locks, the transit through which would have occupied at least 2 hours in place of 12½ minutes. The massive regulating screw sockets are anchored to solid, square iron plates sunk 30 feet in pits tapering toward the surface and filled in with concrete. Each screw is subject to a maximum stress of 1,476 tons. The tank is 230 feet long, 30 feet wide, and 8 feet deep. It is made of sheet iron from ⅜ to ½-inch in thickness on the sides and ½-inch thick on the bottom. It rests on I-beams, which in their turn are supported on hollow shafts bolted to the center of the floating cylinders and giving access to their interior. The cylinders are 27 feet in diameter and 43 feet high, with a displacement of 811 cubic yards, equal to 3,050 tons. A special feature is the water-tight connection between the tank and the canal. The regulating screws were forged in one piece of Siemens-Martin steel and bored down the center to test the uniformity of the metal. They are, approximately, 71 feet long, 11 inches in diameter, and work in massive collar bearings attached to the supports of the tank and also fixed in the overhead platform connecting the towers. Two coupled shafts, driven by a 150-horse power electric motor, actuate the beveled wheels which turn the screws. In 30 days of from 8 to 10 working hours, 600 ships were passed through the elevator.

* * *

The use of electric motors for hoisting purposes in deep mines has reached a stage of development in Germany that warrants serious attention. The advantages of such practice are not obvious at first inspection as it is the universal custom to place the steam plant of hoisting plants in close relation to the hoisting engine, but the development of power from blast furnace gas and coking plants may often in the future make it desirable to transmit power electrically through considerable distances to the pit mouth. Siemens & Halske, Allegemeine Electricitats Gesellschaft and other German electrical firms have built large motors for hoisting purposes of both the direct-current and of the alternating-current type. The makers are prepared to guarantee a steam consumption of 33 pounds per horse power of useful work when electrically developed, which is said to be considerably less than the consumption obtained of the average steam hoisting engine. This presumably is attained by the greater steadiness of load on the engines, especially where storage batteries are used in conjunction for starting purposes, and by the use of a more economical type of engine, running steadily in one direction.

HEAVY GERMAN MILLING MACHINE.

In a recent issue of *Engineering* (London), is illustrated an extremely heavy and powerful milling machine recently built by the Deutsche Niles Werkzeugmaschinen-Fabrik near Berlin for the Stettiner Maschinenbau Actien-Gesellschaft Vulcan, Bredow, Stettin which firm is using it principally on the connecting and parallel rods of locomotives. The principal dimensions of general interest, are as follows:

Width between uprights	33½ inches
Length which can be milled	11 feet 6 inches
Maximum height between top of table and center of spindle	14 inches
Maximum number of revolutions of cutter arbor	35
Minimum number of revolutions of cutter arbor	14.5
Number of speeds	12
Maximum feed per revolution of arbor	½ inch
Minimum feed per revolution of arbor	1-32 inch
Horse power required, about	50
Net weight about	12 tons

This design of machine, however, is made to other dimensions with regard to width, length, or height. The machine illustrated was guaranteed to mill 4 inches per minute in steel forgings over a width of 20 inches and at a depth of

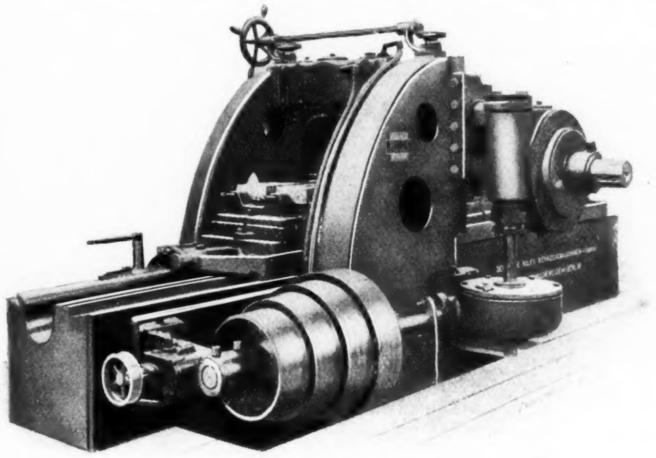


Fig. 1. German Milling Machine weighing twelve tons and requiring fifty H. P. for Driving.

¼-inch. This guarantee was fulfilled, the test result showing a milling feed of 9¾ inches per minute in steel having a width of 16½ inches, while removing 3-16-inch of the stock. One test is cited where the tool was driven by a 50-horse power motor, taking a cut of .20 inch at a speed of 4.17 inches, from a coupling rod 23.62 inches (600 millimeters) wide. These are certainly most satisfactory results. The cutter in use on this occasion is illustrated separately in Fig. 3, herewith, as this form is preferred to that adopted for the cutter shown in the machine as illustrated. The table runs in V ways, the surfaces of which are inclined one toward another, as shown in Fig. 1. The table has longitudinal power feed at ten

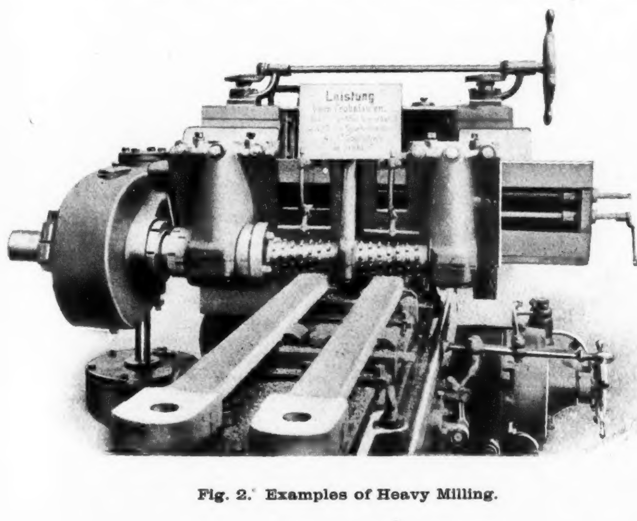


Fig. 2. Examples of Heavy Milling.

different rates; quick adjustment in either direction is provided, with automatic stop. The thrust of the leading screw is taken up by ball-bearing. A counterweight guards the table from any vibration. The machine is driven by cone and two worm gears, giving very smooth running. The second worm gear is not placed direct on the spindle, but separately; the

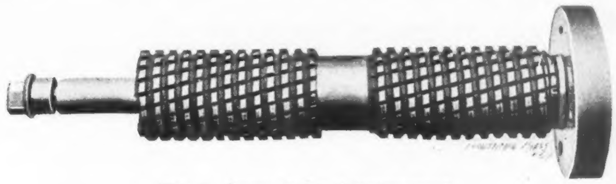


Fig. 3. Type of Spiral Cutter used.

spindle is driven by a special dog to prevent lost motion. Special provision is made for taking up all wear of the cutter arbor. An outer and middle bearing support the arbor, which has horizontal adjustment. The crossrail adjusts vertically by hand.

* * *

NOTES FROM THE SHOPS OF THE CHAMBERSBURG ENGINEERING CO.

The class of work now done by the Chambersburg Engineering Co. is mostly steam hammers, hydraulic riveters, flanging presses, accumulators and other hydraulic machinery of allied nature. A large part of this work is very heavy. The two steel castings for the frame and stake of the 204-inch gap riveter built by this concern weigh about 110,000 pounds. As the overhead works for handling heavy castings are not of the best modern type, the work is not shifted about more than can be reasonably avoided. The practice is to do as much on one machine as possible for that machine before it goes to the next one and so on. In the case of steam hammers the frames must be planed across the top for the steam cylinder and parallel to the frame for the guides. Both jobs of planing are done on the planer to which the job is sent first. Two planers, one of the ordinary type and the other a Detrick & Harvey open-side machine, are used for this work. In the case of the ordinary planer the end of the frame for the steam cylinder is planed with the frame blocked up on the floor, the planer platen carrying the tool and acting as a shaper. A small planer housing is bolted to the platen in a vertical position which carries a tool slide by which lateral adjustment and vertical feed can be secured. The planing of the guides is, of course, an ordinary planer job. The Detrick & Harvey machine handles such jobs in the characteristic manner. The point is that neither planer relinquishes the job until it is completed so far as planing operations go.

Deep pits are provided for erecting steam hammers and hydraulic riveters. The frame of the machine sets down in the pit at such a depth that ordinarily the top where the cylinder and other mechanism is being placed, comes about even with the shop floor. Planks laid across the pit make this work as convenient as could be desired, but if it was done with the frame in the air, it would mean the erection of a staging and much climbing up and down. The largest riveters (204 inches gap) cannot be done in this manner as the pits are not deep enough so they are laid down on the erecting shop floor.

Steel packing rings made from cold-rolled steel are used to a certain extent in the steam hammers. These are rolled up from stock of the exact size required, using a machine which has three rolls. Two of the rolls are provided with five grooves of varying widths and depths to receive the stock and constrain it to roll into one plane. The other roll is left smooth. The smooth roll and one grooved roll are geared together; the third roll acts as an idler and is provided with screw adjusting boxes to vary the curvature of the ring being rolled. Steel packing rings are used in steam hammers on account, of course, of the breakage incident to those made of common cast-iron.

* * *

The Canadian Pacific Ry. has ordered 20 locomotives from Germany in order to secure prompt delivery. This is said to be the first instance of an American road purchasing locomotives in Germany.

Entered at the Post-Office in New York City as Second-class Mail Matter.

MACHINERY

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

66 WEST BROADWAY, NEW YORK CITY.

CHICAGO—1462 Monadnock Block. BOSTON—620 Atlantic Ave.
PHILADELPHIA—Machinery Floor, The Bourse.

LESTER G. FRENCH, Editor.
FRED E. ROGERS and GEO. H. HALL, Associate Editors.

The receipt of a subscription is acknowledged by sending the current issue. Remittances should be made to THE INDUSTRIAL PRESS, and not to the Editors. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Domestic trade is supplied by the American News Company or its branches.

We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

JUNE, 1903.

NET CIRCULATION FOR MAY, 1903,—27,229 COPIES.

MACHINERY is issued in three editions—the Engineering Edition, printed on coated paper throughout, each volume comprising 650 reading pages and forty-eight 6 x 9 data sheets—price $2.00 a year; the Shop Edition, printed on super-calendered paper, comprising 430 reading pages, devoted to practical shop matter—price $1.00; and the Foreign Edition, which comprises the same matter as the Engineering but is printed on thin paper for transmission abroad—price $3.00 a year.

In setting up so simple a machine as a blacksmith's tilt hammer, there are at least two conditions affecting the drive that must be properly met to get satisfactory action: First, the belt should run in the direction that brings the tightener pulley on the slack side of the belt; otherwise the smith must bring an abnormally heavy pressure on the treadle when using the hammer. With the tightener on the slack side of the belt, a slight pressure usually suffices to drive the hammer at top speed. Although this may seem obvious to most mechanics, it apparently is not to some. We remember a tilt hammer that ran for years with the tightener on the tight side of the belt. The consequence was that a helper had to accompany the smith to the hammer each time it was used. The second condition referred to is that the center distance between the countershaft pulley and the crankshaft pulley does not exceed a certain distance, say 7 or 8 feet. If it is greater than this distance, say 12 feet or more, trouble will likely be experienced in getting and keeping the driving belt the right length. If it is slack enough to allow running freely over the lower pulley when not in use, the tightener pulley will have to move through too great a distance to start the machine to work. To overcome this trouble the belt will probably be cut so short that it rubs and frets against the lower pulley and soon wears itself out.

* * *

CHANGE GEAR DEVICES AND GEARED FEEDS.

We begin this month a series of articles upon change gear devices for engine lathes by the author of the recent series upon shop construction. In common with others directly interested in lathe construction, Mr. Perrigo has spent a great deal of time investigating "the state of the art" with respect to such devices; but he has also gone one step further and prepared a manuscript for publication upon the results of his researches. While the articles deal solely with devices designed for screw cutting, they embody the principles of similar mechanisms that are to be found on various machine tools for feeding the tool in the ordinary process of machining. It is hardly necessary to say that the series is timely and that it will add another to the important articles upon machine construction, which have been characteristic of the columns of MACHINERY.

Nests of gears for machine feeds have been in limited use for many years on an occasional drill press or engine lathe and have been employed regularly on the Bullard boring mill and Becker miller from the first; but it was not until W. P. Norton became associated with the Hendey Machine Co., Torrington, Conn., and the latter firm took up the Norton change-gear device that a geared feed became popular. One of the first to build a lathe with a change gear mechanism having a nest of gears was Prof. John E. Sweet, and he has written us as follows upon the subject:

"The first application in practical form of fixed change gears that I know of was by Ferris and Miles, who exhibited a lathe at the Centennial with a projecting spindle outside the bed, carrying eight gears, if I remember correctly, into which a tumbler gear, swinging on the screw and engaging a gear on the screw, communicated the motion.

"The mechanism was in principle very like the Hendey-Norton, with this marked difference—that Ferris and Miles' was outside the bed, whereas the Hendey-Norton mechanism is inside.

"The next, so far as I know, was the one I designed while at Cornell in 1878, and which was built in the University of Wisconsin in 1881 or 1882 and illustrated in the *American Machinist* in 1889, or thereabouts.

"This I believe to have been the first lathe with the change gears inside the bed, but really Hendey and Norton are entitled to the credit for what has been done, because they are the ones who built up such a business out of it that others have been forced to follow.

"It is not so much who did the thing first as who made the thing go."

* * *

IS IT A FAD?

The changes in machine tools during the past ten years have all been in the direction of getting more work out of the machine in a given time. This has come about through the introduction of automatic features in some instances, but more generally through increase in weight and stiffness, more powerful drives, more speed changes and the use of nests of gears by which not only is a stronger and more positive feed obtained, but, what is more to the point, a feed exactly adapted to the tool and the work. Lathe manufacturers are quite generally adopting or considering the adoption of some quick-change gear device for screw cutting, and in some instances for the regular feeds as well, while makers of milling and drilling machines are following in their footsteps with similar feed arrangements.

The question naturally arises, Is this drift toward quick-change devices for screw-cutting and turning anything more than a fad? Many contend that a lathe with such mechanism is too expensive, and liable to give less accurate results; that a milling machine is, after all, better with a belt drive; that screw-cutting is done so seldom that it is no burden to change the gears by the old method, and so on to the end. There is some truth in these claims, and it is a fair question whether, after all, a good, strong belt-driven feed, and the old system of separate change gears are not as satisfactory as any, for the majority of work.

The fact remains, however, that the most expensive luxury around a machine shop of the present day is considered to be the factor of time. Expensive machines are considered a better investment than cheaper ones, provided they will *save time.* A machine, therefore, which will give a mechanic just the speeds he wants and just the feeds he wants, whether in screw-cutting, turning or what not, and give them quickly, is bound to be a time saver and so is deservedly popular. It is this which has made the multiple voltage system of independent driving so well liked and if one is going to the expense of installing so elaborate an arrangement as this to secure convenient speed manipulation of machine tools, he ought by rights to have the machines equipped with equally as good a feed mechanism to go with it. Geared feeds have got beyond the fad period. While it is easy to see that there are many places where it would not pay to so equip a machine, any more than it would with a multiple voltage drive, we believe that fixed-gear mechanisms, both for feeds and screw-cutting, will be thought more and more essential in order to get the greatest possible amount of work out of the machine.

HIGH-SPEED PLANER WORK.

We have received a communication from the foreman of a large machine shop, doing much heavy planing, inquiring what is being done in the matter of fast-cutting speeds on planer work with the new high-speed steels. Considerable data and other information have been published regarding fast-cutting speeds on lathes, but little has been said about increased planer speeds. The principal planer manufacturers having been solicited for information on the matter, with one or two exceptions, have expressed the opinion that from 25 to 30 feet per minute is about the limit of cutting speed that should be attempted with the larger planers built by them, regardless of the speed the steel will stand. Higher speeds than these are believed by most of the planer builders to cause so much lost time and expense for repairs and grinding tools that there is little, if any, gain in the end. They are not, however, unanimous in this opinion, as will be seen from the following extracts which are substantially as expressed in the letters received:

William Sellers & Co. say they have built planers up to 10′ × 10′ square between the housings with variable cutting speeds from 3 to 48 feet per minute and with a constant return speed of 96 feet per minute, which are in very successful operation. They have recently applied the variable speed feature to one of their 10′ × 10′ × 36′ shop planers.

The G. A. Gray Co. do not believe that planers larger than 30″ × 30″ can be run faster than 30 feet successfully as a general thing, although they have built one 30″ × 30″ for a customer who claims to be running it at the rate of 66 feet cutting speed. They have found in their own shop experience that large surfaces like planer platens can be most economically handled at from 20 to 25 feet per minute and they do not recommend running faster than the latter speed.

The Woodward & Powell Planer Co. say that they have run their planers at a speed of 40 feet per minute, cutting a fine quality of cast-iron. The cutting tool was made of the best steel they could obtain and the chip was light. They are of the opinion that this speed is too high for most practical purposes and recommend a cutting speed of 20 to 30 feet per minute with a return speed of about 50 to 60 feet per minute.

The Niles Tool Works branch of the Niles-Bement-Pond Co., say they are conversant with cases where a cutting speed of from 25 to 30 feet is employed successfully, and believe from their own experience and that of others using heavy planers, that 30 feet per minute is perhaps as economical as any higher speed that might be obtained.

The Whitcomb Manufacturing Co. have a 26″ × 26″ × 12′ second-belt-drive planer running at a cutting speed of 45 feet, which is working successfully on very difficult work, being planer crosshead work, and digging out and finishing angular and square gibs. Another planer of the same type in their shops is running at a speed of 36 feet per minute. They believe that for planers 36″ × 36″ and larger, 30 feet per minute is about the limit where only one cutting speed is available, but if two cutting speeds are available they believe that much higher speeds than 30 feet can be used much of the time on ordinary work.

In regard to the value of more than one cutting speed, the Betts Machine Co. say that there are many instances where higher cutting speeds could be used than would otherwise be practical. For one uniform cutting speed on heavy planers, they recommend 25 feet per minute.

The Cincinnati Planer Co. have one of their 48″ × 48″ planers running at a cutting speed of 35 feet per minute at the Schenectady plant of the American Locomotive Co., which is doing good work and giving very good satisfaction at that speed. In their own shops this firm have a 24″ × 24″ planer running at a constant cutting speed of 38 feet per minute. One of their 36″ × 36″ planers is run at a cutting speed of 42 feet per minute on light roughing cuts, but is slowed down for finishing, a variable speed countershaft being provided for this purpose. Their other planers including the large ones are run at 26 to 30 feet per minute. Their experience is that the majority of shops are not able to run at cutting speeds much higher than 24 to 25 feet per minute. One of their planers 48″ × 48″ × 18′ is running at the Elliott Frog & Switch Works at a speed of 24 feet per minute, working on steel rails, but so far the only tool steel found to stand up to this severe work is Novo.

Another firm, that did not wish to be quoted, wrote conservatively regarding the higher cutting speeds, believing that the most efficient results are obtained with speeds of 15 to 20 feet per minute. This firm, however, has recently built two planers for a railroad shop to plane 26 feet long with a cutting speed of 30 feet per minute.

The Bement, Miles & Co., branch of the Niles-Bement-Pond Co., have an extremely heavy 72-inch frame planer used in the Juniata shops of the Pennsylvania Railroad working successfully at a cutting speed of 40 feet per minute, but it was not built for such high speed. Another planer in these shops is planing cylinders at about the same cutting speed.

* * *

NOTES AND COMMENT.

Some of the expedients resorted to in the manufacture of very fine wire are most ingenious and interesting. It is generally known that platinum wire can be drawn to exceedingly small diameters, even as slight as 1-50,000 inch, but how it is done is another matter. We understand that one method is to reduce the wire to as small a diameter as possible by ordinary drawing methods and then to coat it with a heavy layer of silver. The compound wire is then drawn down until the interior platinum wire is reduced to the desired diameter, and then the silver is dissolved off, leaving the platinum wire intact.

In a letter to *Engineering* (London) on the stresses set up in a crank web when shrunk on its shaft, Mr. Albert Kingsbury, Worcester, Mass., concludes that a shrinkage allowance of 1-1000 the diameter (0.001 inch to 1 inch) is about as much as can be safely made if the stresses are kept within the elastic limit for wrought iron and steel. To this should be added a slight allowance for roughness of the shaft, say 0.001 to 0.002 for shafts of fairly large diameters. He intimates that shrinkage allowances of 1-350 to 1-500 the diameter are quite certain to cause the elastic limit to be exceeded. For cast-iron webs the shrinkage allowance should be even less than with iron or steel to avoid exceeding the elastic limit.

The development of the electric street railway has created a class of mechanical officials who are neither "fish nor fowl" so far as the existing railway and electrical organizations go. The master mechanic of a street railway line, while he may be a practical electrician all right, scarcely feels at home at a meeting of the electrical engineers, and he certainly feels equally isolated at the railway master mechanic's conventions. A society for this body of men, called the American Railway Mechanical and Electrical Association, was organized in Cleveland, Ohio, last February, and will hold its first annual convention at Saratoga, N. Y., September 1-4, in conjunction with the meeting of the American Street Railway Association. A number of interesting and profitable papers are promised.

In the February issue mention was made of a new and valuable use that has been discovered for carborundum, and that was as a lining for covering the firebrick of furnaces with a highly refractory coating. It appears from recent discoveries made at Niagara Falls by Mr. Acheson that "siloxicon," which is a somewhat different product from carborundum, is more likely to be largely used for this purpose since it is a self-binding material, having only to be mixed with water to be applied. Siloxicon forms in the electric furnace at a temperature of from 4,500 to 5,000 degrees, whereas carborundum is said to require about 7,000 degrees F. Siloxicon can be used alone as a refractory covering for furnace interiors, but for some purposes it is better to use a binding agent such as liquid tar, asphaltum, pitch, molasses, glue or other materials of a hydrocarbon or carbonaceous nature. The prospective field for the use of this refractory lining is large, as it will be valuable for muffles, crucibles, furnaces, tuyeres and other apparatus in which firebrick is exposed to very high temperatures.

CONSTANTS FOR VARIABLE SPEED DEVICES.

JOHN S. MYERS.

One of the live problems at the present time among machine tool designers is the perfection of a variable speed device capable of transmitting the horse power required for driving the modern machine tools.

The advent of the new tools permitting much higher cutting speeds and the now increasing tendency of manufacturers toward as little hand scraping as possible but instead, inserting broad flat tools, and running very slow, performing the scraping operation in the machine, have made a wide range of speed imperative. This has necessitated greater back-gear ratio, more ratic at the cone and usually more and finer steps. It is here that the variable speed device usually has its origin. Most of these operate upon the principle of expanding disks or cones, which is a variation of the cone pulley problem. There are, however, quite a number of variable quantities involved in a simple pair of cones that sometimes prove troublesome.

The following formulas and table of constants were developed for use in determining the quantities pertinent to the designer in a speed-varying device operating on the principle of expanding disks or pulleys, a pair of such disks being belted together. It is quite evident that the formulas are equally applicable to the ordinary stepped cones in more general use or to a nest of gears on parallel shafts. The writer hopes the appended table may be useful in this connection:

Let D = Maximum cone diameter in inches.
D_1 = Minimum cone diameter in inches.
D_2 = Even cone diameter in inches.
D_3 = Variable shaft cone diameter for mean speed.
D_4 = Constant shaft cone diameter for mean speed.
R = Ratio of maximum to minimum speeds.
S = Speed of constant and of variable shaft at even cone diameters.
S_1 = Maximum speed of variable shaft.
S_2 = Minimum speed of variable shaft.
S_3 = Mean speed of variable shaft.
V = Maximum belt velocity feet per minute.
V_1 = Minimum belt velocity feet per minute.
V_2 = Mean belt velocity feet per minute.
V_3 = Velocity at mean number of R. P. M.

Then

$$D = D_1 \sqrt{R}$$

$$D_1 = D\left(\frac{1}{\sqrt{R}}\right)$$

$$D_2 = \frac{D + D_1}{2} = D\left(\frac{1 + \frac{1}{\sqrt{R}}}{2}\right)$$

$$D_3 = D_2\left(\frac{4}{\sqrt{R} + \frac{1}{\sqrt{R}} + 2}\right) =.$$

$$D_2\, w = D\left(\frac{2 + \frac{2}{\sqrt{R}}}{\sqrt{R} + \frac{1}{\sqrt{R}} + 2}\right) = D\,y$$

$$D_4 = D_2\left[2 - \left(\frac{4}{\sqrt{R} + \frac{1}{\sqrt{R}} + 2}\right)\right] = D_2\, z$$

$$D_4 = D\left[1 + \frac{1}{\sqrt{R}} - \left(\frac{2 + \frac{2}{\sqrt{R}}}{\sqrt{R} + \frac{1}{\sqrt{R}} + 2}\right)\right] = D\,x$$

$$S = \sqrt{S_1 S_2}$$

$$S_1 = S\sqrt{R}$$

$$S_2 = S\left(\frac{1}{\sqrt{R}}\right)$$

$$S_3 = \frac{S_1 + S_2}{2} = S\left(\frac{\sqrt{R} + \frac{1}{\sqrt{R}}}{2}\right) = S\,v$$

$$V = S\,\frac{\pi D}{12}$$

$$V_1 = \frac{V}{\sqrt{R}}$$

$$V_2 = \frac{V + V_1}{2} = V\left(\frac{1 + \frac{1}{\sqrt{R}}}{2}\right)$$

$$V_3 = V\left[1 + \frac{1}{\sqrt{R}} - \left(\frac{2 + \frac{2}{\sqrt{R}}}{\sqrt{R} + \frac{1}{\sqrt{R}} + 2}\right)\right] = V\,x$$

TABLE OF CONSTANTS.

R	$\sqrt{R}$	$\frac{1}{\sqrt{R}}$	$\frac{1+\frac{1}{\sqrt{R}}}{2}$	v	w	y	x	z
1.5	1.224	.817	.909	1.021	.990	.924	.893	1.010
2.	1.414	.707	.854	1 061	.971	.828	.879	1.029
2 5	1.581	.633	.817	1.107	.944	.775	.858	1.056
3.	1.732	.577	.789	1.154	.928	.732	.845	1.072
3.5	1.871	.534	.767	1 203	.908	.696	.838	1.092
4.	2.000	.500	.750	1.250	.889	.667	.833	1.111
4.5	2.121	.472	.736	1.296	871	.641	.831	1 129
5.	2.236	.447	.724	1.342	.854	.618	829	1.146
5.5	2.345	.426	.713	1 386	.839	.598	.828	1 161
6.	2 450	408	.704	1.429	.823	.580	.828	1.175
6.5	2.550	.392	.696	1.471	.809	.563	.829	1.191
7.	2 646	.378	.689	1.512	.796	.549	.829	1.204
7.5	2.739	.365	.683	1.552	.784	535	.830	1.216
8.	2.828	.353	.677	1.592	.772	.522	.831	1.228
8.5	2.915	.343	.672	1.629	.761	.511	.832	1.239
9.	3.000	.333	.667	1.667	.750	.500	.833	1.250
9.5	3.028	.330	.665	1 679	.747	.497	.834	1.253
10.	3 162	.316	.658	1.738	.731	.481	.836	1.269

* * *

CALCULATION OF MOMENT OF INERTIA OF A PLANE FIGURE.

SANFORD A. MOSS.

The calculation of the moment of inertia of a complicated figure is a laborious operation, and unless great care is taken mistakes are likely to be made. The following systematic method of carrying out the various computations will be found to reduce the labor and to give certainty of a correct result.

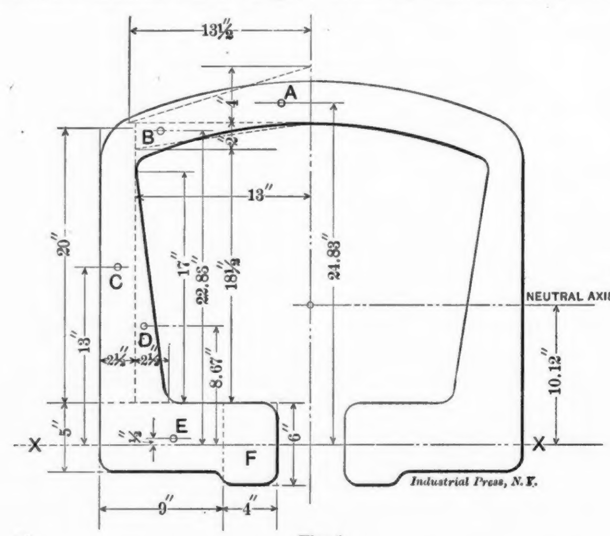


Fig. 1.

Let Fig. 1 be a figure whose moment of inertia is to be found. A dimensioned sketch of the figure must be made. A free-hand sketch will do if made approximately to scale. Divide the figure up into rectangles and triangles, as indicated by the dotted lines, approximating the figure as closely

as the desired accuracy requires. From the given dimensions find the breadth and height of each of the various rectangles and triangles. The "breadth" is the dimension parallel to the direction of the neutral axis; and the "height" the dimension perpendicular to it. Of course the direction of the neutral axis must always be known in the beginning.

Select a line parallel to the known direction of the neutral axis, as a reference axis. This we shall call the "X axis." It may be at any convenient point on the figure. However, the work is slightly simplified if the X axis is drawn through the center of gravity of the lowest one of the rectangles or triangles. Find the distance from the X axis to the centers of gravity of the rectangles and triangles.

The center of gravity of a rectangle is, of course, at half its height. The triangles should all be selected so that the base is parallel to the neutral axis. Then the center of gravity will be at a distance from the base equal to 1-3 of the height.

Set down the various breadths, heights and distances from the X axis to the centers of gravity as dimensions of the figure. These dimensions can usually be found by mental computation. If the figure is drawn accurately to scale the dimensions may be checked by being gone over with a scale afterward.

Letter the rectangles and triangles A, B, C, etc., beginning with the one whose center of gravity is farthest from the X axis and proceeding successively according as the distances of the centers of gravity from the X axis diminish. If the figure is symmetrical, or if for any other reason there are several rectangles or triangles of the same height, and whose centers of gravity are at the same distance from the X axis, they are all to be counted together as a single rectangle or triangle whose breadth is the sum of the several breadths.

Rule off a table as shown by Fig. 2, of course leaving the space for the various numbers blank for the present. In column 1 place the designating letters of the various rectangles or triangles. In column 2 place the letter *R* or *T* according as the figure is a rectangle or a triangle. In column 3 place the breadth. This is to be the sum of all of the breadths, if there are several rectangles or triangles which have the same height and which are at the same distance from the X axis, as already stated. In column 4 place the height, and in column 5 the cube of the height. This is most conveniently found from a table of cubes. The squares of the height for column 12 may be filled in at the same time.

In column 6 place the products of the numbers in columns 3 and 4, dividing by 2 for triangles. This evidently gives the areas of the various figures. In this, as in all of the numerical calculation, care must be taken. The lower scale of a 10-inch slide rule will give sufficiently close results *if care is taken to estimate the last figure.*

It is now becoming customary to make all engineering calculations on some one of the more accurate calculating instruments, such as Thatcher's or Fuller's slide rules. The sample calculation given was made on a slide rule with a scale 250 inches long.

In column 7 put down the distances of the various centers of gravity from the X axis. In column 8 put down the products of the figures of columns 6 and 7. Find the totals of columns 6 and 8 and divide the total of column 8 by the total of column 6. The result will be the distance of the neutral axis from the X axis, which we will call Z. Subtract Z from each of the numbers of column 7 and put down the result in column 9. Negative results must of course be indicated with a minus sign.

In column 10 put down the products of the numbers in columns 6 and 9, giving the negative sign when it occurs. Add together all of the positive terms in column 10 and then all of the negative terms. The results will be equal if the work up to this point has been done correctly. In column 11 put down the products of columns 9 and 10, and also the products of columns 3 and 5, dividing the latter by 36 for triangles and 12 for rectangles. Add column 11 and the result will be the desired moment of inertia.

In order to be sure that all of the numerical work has been done correctly, the moment of inertia may be found in another way for a check. This is done with 12, 13, 14 and 15. Of course if no check is desired these columns need not be filled out.

In column 12 put the squares of the numbers of column 4. In column 13 put the squares of the numbers in column 9, and also the results obtained by dividing column 12 by the number 18 for triangles or the number 12 for rectangles, calling these quotients "*e*." In column 14 add the two numbers for each line of column 13. In column 15 put down the products of columns 14 and 6. The sum of this column will be the moment of inertia and it should agree with the previous value. If it does not, there is a mistake in some of the numerical work. The sum of the two numbers for each line in column 11, should be the same as the number of column 15. This fact will assist in the location of a mistake. If the positive and negative parts of column 10 are equal and if columns 11 and 15 give the same sum, the value thus found for the moment of inertia is almost absolutely certain to be correct.

FIG. 2. FORM FOR CALCULATION OF MOMENT OF INERTIA OF A PLANE FIGURE.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Part.	R or T	Breadth.	Height.		$\frac{bh}{2}$ if T bh if R	Distance from X axis.		x − Z		y × ay and $\frac{h^3 \times b}{36}$ if T $\frac{h^3 \times b}{12}$ if R		y^2 and $\frac{h^2}{18}$ if T $\frac{h^2}{12}$ if R		
		b	h	h^3	a	x	a x	y	a y		h^2	y^2 and e	$y^2 + e$	$a \times (y^2 + \ )$
A	T	27	4	64	54.	24.83	1340.8	14.71	794 3	11685 48	16	216.38 .89	217.27	11732
B	T	26	2	8	26.	22.83	593.5	12.71	330.4	4200 6	4	161.54 .22	161.76	4206
C	R	5	20	8000	100.	13.	1300.0	2 88	288.0	830 3333	400	8.29 33.33	41.62	4162
D	T	5	17	4913	42.5	8.67	368.4	−1.45	1412.7 −61.6	89 682	289	2.10 16.06	18.16	772
E	R	18	5	125	90.	.5	45 0	−9.62	−865.8	8329 187	25	92 54 2.08	94.62	8518
F	R	8	6	216	48.	0.	00.0	−10.12	−485.7	4916 144	36	102.41 3.00	105.41	5060
					360.5		3647.7		−1413.1	34449				34450

$360.5 = \text{Area} \quad \frac{3648}{360.5} = Z = 10.12$ $\quad$ $34449 = \text{Moment of Inertia.}$ $\quad$ $34450 = \text{Moment of Inertia (check)}$

* * *

The amount of flow over Niagara Falls has been estimated to be 275,000 cubic feet per second or 500 tons per minute. As the total fall available from the beginning of the upper rapids to the foot of the cataract is 216 feet, the theoretical horse power figures to more than 6,000,000, of which about one-sixteenth will be utilized in the near future.

FLYWHEELS,

THEIR PURPOSE, PRINCIPLE AND DESIGN—CALCULATION FOR SPEED VARIATION.

WILLIAM BURLINGHAM.

This article is not supposed to be highly mathematical or to enter into the nice points of flywheel design. It will have served its purpose if it gives the working machinist a fairly good idea of some of the difficulties that are inherent in this work, and the reasons for the adoption of the varying types of wheels.

What is the purpose of a flywheel? In a steam engine or other reciprocating machine, where reciprocating motion is transformed into one of rotation, there must always be a variation in the amount of rotative effort, without regard to how constant the force of reciprocation may be. Therefore a varying and corresponding change of acceleration must take place, either plus or minus, coincident with the change of effort. In addition to this, the work required of the engine is constantly fluctuating and this also varies the effort.

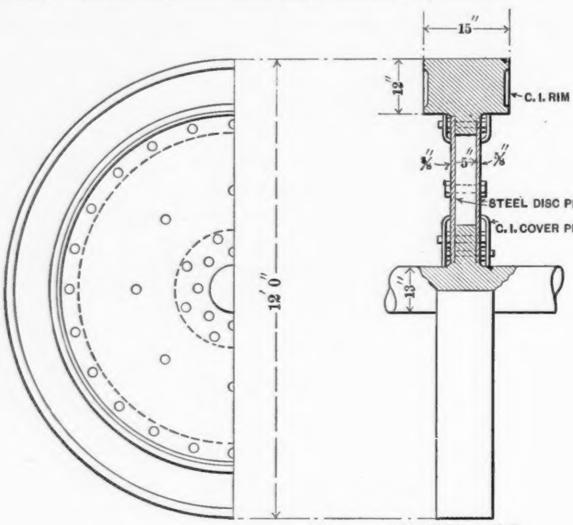


Fig. 1. Steel Disk Flywheel.

As regards the attachment of flywheels to machines, for the conversion of mechanical into electrical energy, the uniformity of the required speed is still more important and the revolutions of the machine must be kept within a variation of certain limits; or, in other words, the speed must be practically constant. The governor, of course, comes into play to help the flywheel out, the duties of the two being respectively as follows: The flywheel, to control the tendency to change in speed, due to an unequal amount of internal effort in the engine; the governor, to limit the variation from the change in the external load. In addition to this, the flywheel practically automatically compensates or smooths over any quick changes of the external load; if this quick external load continues to change for any appreciable length of time, the governor gradually comes into action.

The principles involved are the following: As work spent is always equal to work accomplished, it follows that, if we neglect friction, the work represented by the "mean pressure on the piston acting over the length of the stroke" must equal the tangential turning effort on the crankpin, acting through half a revolution, the latter product representing the resistance. If equality existed at all points of the stroke between the work spent and the resistance, a flywheel would not be needed; but as it is, when a piston transmits more pressure to the crankpin than is necessary for the resistance to be overcome, the wheel must absorb the surplus, and the velocity of the wheel is accelerated by this surplus and work is stored up in it. If the piston fails to transmit sufficient tangential pressure either from want of actual pressure or because the crank is near or at the dead center, the work stored in the wheel is given out to the shaft again. When the engine reaches its mean speed, which speed may vary from day to day in proportion to the work it is doing, it is only the fluctuations above or below these mean speeds that the flywheel has to look out for.

The influences of the inertia of the reciprocating parts is important in all large engines, where the moving parts have great mass and the velocity is considerable. The effect of inertia may be considered as a force acting in opposition to the steam pressure at the inner dead center, and in conjunction with it at the outer dead center. The flywheel does nothing to make the mean effort of the engine equal to the mean resistance.

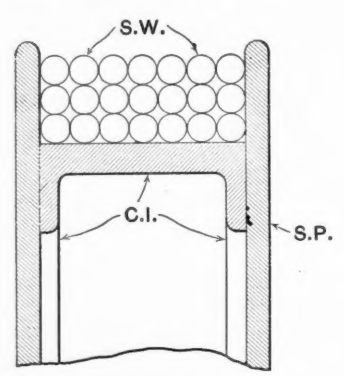
The ordinary flywheel used in this country is built of cast iron, and we have had many serious accidents from the bursting of these wheels, because of bad design, hidden flaws, or wheels that were run way above their designed speed. Wheels will run away now, and will run away until the end of time, and the only thing we can do is to make them strong enough to endure until the engineer can reach the throttle and close down the engine.

Fig. 1 shows a novel type of wheel suitable for the severe work of a traction plant. It is used on a 600 kilowatt set for power and lighting in the works of Messrs. Workman, Clark & Co., Ltd., Belfast, and was designed by Mr. Chas. E. Allen, a director of that firm. The diameter is 12 feet and the advantages claimed for it, which seem correct, are as follows:

1st. The rim is continuous, and the strength maintained, therefore, practically to the full. 2d. The number of bolts in the rim being much more numerous than spokes, the stresses that occur, due to the bending of the rim between the points of support, are correspondingly less. 3d. The steel disks connecting the rim with the hub are made very strong to resist the great torques of sudden changes of speed, a very important matter in a flywheel for electric traction. 5th. It is exceedingly cheap to make. 6th. The stresses in the arms, due to the cooling and shrinkage of a cast iron wheel are absent from a wheel of this type.

If a larger wheel of this type were made it could be made with the rim in sections, when all the above advantages would obtain, except the first. Another type of wheel, claimed to have been originated by Prof. Sharp, is shown in Fig. 2.

Steel wire of great tensile strength is wound around the periphery of the wheel. With a well-made wheel of this type it is practically safe to run it at three times the velocity of an ordinary cast iron wheel. Hence it would store nine times the energy for the same weight, at the same radius of gyration, as a cast iron wheel.



CROSS SECTION
S.W. = Steel Wire
S.P. = Steel Plates
C.I. = Cast Iron
Fig. 2.

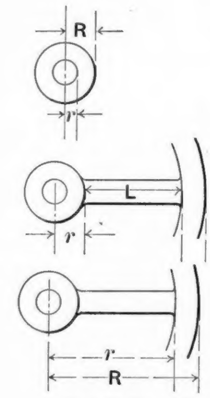


Fig. 4.

A wheel of this type is used at the Mannsmans Tube Works. About 70 tons of steel wire was wound on the wheel with a tension of about 50 pounds. The flywheel was 20 feet in diameter and ran at 240 revolutions per minute, equal to a peripheral speed of about 250 feet per second. The speed of a cast-iron wheel of the same diameter would be about 100 feet per second.

Danger of Flywheels Bursting.

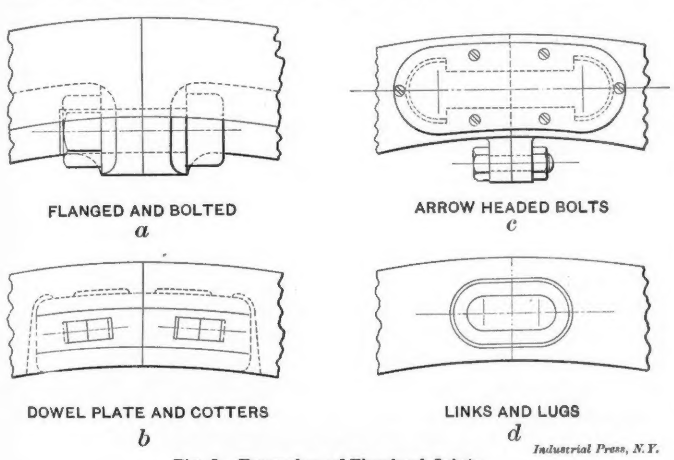
As regards the danger of flywheels bursting, Professor Barr states that it is not realized how dangerous they are and mentions a case in point. It was on an experimental engine. The makers of the flywheel on which an experimental brake was used had, contrary to his wishes, and entirely on their own responsibility, made the flywheel with a solid boss. One evening, during the run, a report like a gunshot was heard and the observers noticed that the flywheel was running out of

true. The rim of the wheel was just warm, about as warm as one's hand. The engine was stopped and they found three of the arms out, and six broken. The middle one was open about 3-32 of an inch. There must therefore have been an enormous initial stress in the arms. There were two flywheels on the engine and the makers were told that they must replace both. They said they would replace the broken one with a new one having a split boss and cut the boss of the other wheel. They were warned as to what would happen, but they put the wheel in a slotting machine and before they had cut half way through one side of the boss, the stresses of the wheel completed the job in a manner astonishing to the workman running the slotter.

Great care must be taken regarding test specimens, as a test specimen cast from the same melting as the wheel does not necessarily indicate the same strength as that in the wheel. Test specimens vary also according to the way they are cast, so that a high factor of safety must be allowed in all cast wheels—say from 12 to 15.

Mr. C. A. Matthey, Scotland, says that, considering the ultimate of British cast-iron as 16,000 pounds, it was safe to assume a factor of safety of 8, with a speed of 140 feet per minute; the arms to be cast with the rim but without the hub, thus avoiding cooling stresses, the hub being conscientiously fitted afterwards. This involves entering the arms sideways and not radially into pockets in the hub. He justifies this by exampling the same construction in cane mill practice, where both flywheels and gear wheels are thus made, standing up well under the extremely severe work of these mills. He thinks that the attachment of the arms to the rim, when separate from solid rims, should be such as to drive the rim around without pulling it in toward the center. Let the rim support itself by its own tensile strength without radial pressures at a number of points.

The strength necessary in the arms of a flywheel has little if anything to do with the centrifugal force, and their sections should be proportioned to the driving moments they exerted in storing up energy in the rim and in re-delivering it to the shaft. In certain kinds of engine service a good rule is to make the flywheel arms strong enough to pull up the wheel from full speed to a dead stop in one revolution.



Industrial Press, N.Y.

Fig. 3. Examples of Flywheel Joints.

From Mr. A. Marshall Downie's B. Sc. paper in Trans. of Ins. Engineers and Shipbuilders, Scotland, I quote the following: "The combined cross-sectional area of the arms in well designed wheels of the type used for electric traction, etc., is generally from two to three times the cross section of the rim. The strength of the arms as beams, fixed at the inner end and loaded at the outer end, with the force required to produce an acceleration, either plus or minus, in the mass of one segment, while changing the velocity through the limits specified in the time elapsing between two consecutive points of coincidence of the actual and mean crank effort lines, should also be considered; and this, together with the resistance to shearing by the same load, should not tax the material above one-eighth of its ultimate load."

The fixing of the arms to the hub is usually by means of bolts or cotters and their strength in double shear should be equal to that of the arm in shear or tension, whichever is greater.

Flywheel Rim Joints.

Several forms of rim joints are in use for flywheels. Among the principal ones are the following: *a*, flanged and bolted; *b*, dowel plate and cotters; *c*, arrow-headed bolts; *d*, links and lugs. As illustrated in Fig. 3, the following points must be observed:

a—In flanged and bolted joints, the bolts should be as near the rim as possible, consistently with getting a deep flange. The bolts should be carefully fitted at each end and cleared in the center, so that the stress on them should be tensile rather than shearing. They should all be initially stressed by screwing up, if possible to the same amount.

b—The accurate machining and fitting of the dowel plate and cotter joint is most important. It should be so designed that the strength of the cast-iron, cotters and portion of the dowel plate in shear is equal to the strength of the portion of the dowel plate in tension. The accuracy with which the initial stress in this form of joint can be adjusted is an important feature in its favor.

c—The arrow-headed bolt joint is a shrunk joint, and is open to the objection that the initial stress on the bolts due to the shrinkage is a more or less unknown quantity and the ultimate stress, therefore, indeterminate. The points to be attended to in its construction are accurate machining between the lugs on the bolts and rim, and provision for clearance at the center, for the same reason as noted in *a*.

d—The link and lug joint is also a shrunk joint and subject to the same objections as *c* on that score. If made with the lug projecting, as shown in the figure, it has the advantage that the section of the rim is not diminished at the joint. The increase of weight, however, which such a form necessitates is a good reason for removing the position of the joint nearer one arm. From the experiments of Professor C. H. Benjamin in the proceedings of the American Institute of Mechanical Engineers and from the workings of the engines of the Metropolitan Street Railway, Mr. Downie has drawn the following conclusions:

A good average value for the energy necessary to be stored in flywheels for electric lighting purposes is 2.9 foot-tons per electric horse power; and in traction plants, 4 foot-tons.

Where practicable, cast-iron flywheels should have one-piece rims, but when jointed the best form is the link and lug type, where such can be adopted without inconvenience, and the next best is the dowel plate and cotter. Flanged and bolted joints should be avoided and the best place for a joint is near one arm.

One-piece rim cast-iron flywheels may be run at a peripheral speed of 100 feet per second with the certain knowledge that the factor of safety is not under 12, and link-jointed wheels may also be run at that speed and have a factor of safety of 8. A lower factor of safety should not be used, and flange-jointed wheels should not be run above 70 to 75 feet per second. Built steel wheels may be run up to 130 feet per second. Arms should be joined to rims with large fillets and their fixing to the hub should be carefully fitted.

The best material of its kind should be used in the construction, and homogeneity should be insured as far as practicable by having test bars from each segment cast and proved.

Calculation for Speed Variation.

For the design of flywheels pertaining to lighting and traction the paper of Mr. Downie, with discussion, may be found in the Trans. Ins. Engs. and Shipbuilders, Scotland, and is recommended to the reader.

For regular engine work, however, two sets of formulas are presented from Mr. Foley and from Mr. Marichal. The formulas from Mr. Foley are as follows:

Given permissible variation in velocity above and below mean, to find necessary weight of rim.

$$W = \frac{\text{area piston sq. in.} \times \text{M. E. P. in lbs.} \times \text{stroke in ft.} \times x \text{ per cent.} \times 32.2 \times C}{(\text{Rim velocity in feet per second})^2}$$

W = weight of rim in pounds.

$\frac{1}{C}$ = fraction that variation of velocity from mean velocity is of mean velocity.

x per cent. = percentage that variation of work from mean resistance bears to mean resistance, viz., to mean work.

Example: Suppose an engine 18 inches by 30 inches stroke to have a flywheel whose diameter is four times the stroke, or 10 feet. Assume the variation of work from mean work to be 30 per cent. What weight should the flywheel rim be so that the variation of velocity shall not be more than $\frac{1}{50}$ on each side of mean velocity?

x per cent. = 30.

$C = 50$.

Area piston = 254.5 square inches.

Stroke = 2.5 feet. We have,

Mean pressure 28.2 pounds.

Mean work or mean resistance during one stroke = 254.5 × 28.2 × 2.5 = 17942.2 foot pounds; and 30 per cent. of this equals 5382.6 foot pounds.

$$\frac{W}{32.2} \times \frac{V^2}{C} = 5382.6$$ foot pounds, and at 120 revolutions per minute the rim velocity would be 62.83 feet, and C being 50, we have

$$W = \frac{5382.6 \times 32.2 \times 50}{(62.83)^2} = 2195 \text{ pounds.}$$

TABLE.

$S_1 = .097017\ V^2$ Marichal.

V Velocity of Rim in feet per sec.	S_1 Tensile Strength of Metal in Rim lbs per sq. in.	Dia. of Pulley in feet.	Revs. per minute for Rim Speed of feet per second.		
			150	100	70
50	242.5	4	716.7	477.8	324.7
60	349.3	6	477.8	318.5	222.9
70	475.4	8	358.2	238.8	167.1
80	620.9	10	286.5	181.0	133.7
90	785.8	12	238.8	159.2	111.5
100	970.2	14	204.6	136 4	95.5
110	1173.9	16	179.1	119.4	83.57
120	1397.0	18	159.2	106.1	74.28
130	1639.6	20	143.2	95.5	66.85
140	1901.5	22	130.2	86.8	60.77
150	2182.9	24	119.4	79.6	55.71
160	2483.6	26	110.2	73.5	51 42
170	2803.8	28	102.32	67.2	47.75
180	3143.4	30	95.50	63.7	44.57
190	3502 3	32	89.55	59.7	41.79
200	3880.7	34	84.27	56.17	39.33
210	4278.4	36	79 64	53.10	37.08
220	4695 6	38	75.44	50.29	35.21
230	5132.2	40	71.76	47.77	33.44
240	5588.2	42	68.21	45.47	31.83
250	6063.6	44	65.11	43.41	30.38
260	6558 3	46	62.28	41.52	29.06
270	7072.5	48	59.68	39.79	27.85
280	7606.1	50	57.30	38.20	26.74
290	8159.1	52	55.09	36.73	25.71
300	8731.5	54	53.05	35.37	24.76

D = dia of wheel in feet. $S_1 = .000266 \times (D\,N)^2$ for cast iron.

N = revolutions per min. $S_1 = .000292 \times (D\,N)^2$ for steel.

For tandem engines, the effect is cumulative; hence calculate flywheel for each cylinder and add weights.

For quarter-crank compounds, calculate as for tandems and multiply by 0.625.

For three cranks calculate as for tandems and multiply result by 0.4166.

Formula of Marichal:

d = diameter of cylinder in inches.

S = Stroke of piston in inches.

D = Mean diameter of flywheel rim in feet.

N = Revolutions per minute.

V = Rim speed in feet per second.

P = Maximum pressure on piston in pounds per square inch (difference between initial and back pressure).

F = Fluctuation of speed in per cent. of mean speed.

W = Weight of flywheel in pounds.

S_1 = Strain on rim section in pounds per square inch.

a = Area of rim section required to give rim two-thirds the total weight of wheel.

Then

$$W = 76000 \frac{d^2 S P}{(D\,N)^2 F} = \frac{d^2 S P}{V^2 F} \times 208$$

$$S_1 = .000266\ (D\,N)^2$$

$$a = .068 \frac{W}{D}$$

$$F = 76000 \frac{d^2 S P}{(D\,N)^2\, W}$$

Nystrom gives:

P = Radius of gyration of wheel in feet—W = its weight in pounds.

P_1 = Radius of gyration of hub in feet—W_1 = its weight in pounds.

P_2 = Radius of gyration of arms in feet—W_2 = their weight in pounds.

P_3 = Radius of gyration of rim in feet—W_3 = its weight in pounds. (See Fig. 4.)

$$P_1 = \sqrt{R^2 + r^2}$$

$$P_2 = \sqrt{r^2 + r\,L + \tfrac{1}{3} L^2}$$

$$P_3 = \sqrt{\frac{R^2 + r^2}{2}}$$

$$P = \sqrt{\frac{W_1 P_1^2 + W_2 P_2^2 + W_3 P_3^2}{W}}$$

N = Revolutions per minute of wheel.

F = Mean total force acting on piston in pounds.

S = Stroke in feet.

f = Irregularity in fraction of speed (N).

$$f = 1 - \sqrt{1 - \frac{338\,F S}{W P^2 N^2}}$$

$$W = \frac{338\,F S}{P^2 N^2 [1 - (1 - f)^2]}$$

$$N = \frac{18.4}{P} \sqrt{\frac{F S}{W [1 - (1 - f)^2]}}$$

$$P = \frac{18.4}{N} \sqrt{\frac{F S}{W [1 - (1 - f)^2]}}$$

A gas compressor running at $N = 40$, has a mean effective pressure of 57.87 pounds in the steam cylinder, and 68.68 pounds per square inch in a gas cylinder. Their areas being 113.09 and 38.484 square inches. Therefore F = (57.87 × 113.09) — (68.68 × 38.484) = 3,901 pounds. W = 2,276 pounds. P = 1.872 feet. S = 1.5 feet. N = 40.

Example—

$$f = 1 - \sqrt{1 - \frac{338\,F S}{W P^2 N^2}} = .081\ N$$

* * *

The first vessel to surpass the *Great Eastern* in length and displacement was the *Oceanic*, placed in commission in 1899, and since that time there has been a gradual increase up to the present *Cedric*. One reason why the *Great Eastern* was a commercial failure was that sea ports, especially those of the United States, were too shallow to allow her entrance without danger of grounding. But a more important reason was the inability of the shops of that day (1858) to produce boilers and engines commensurate with the requirements of so large a boat.

Near the end of the Civil War the Navy Department built the *Wampanoag* with a single regard to speed high enough to enable her to catch privateers. But her boilers were built for a pressure of only 32 pounds. The *Cedric*, which is designed to make about the same speed, will carry 210 pounds of steam. The plates were small and heavy because rolls were small and the material (iron) required much thickness to give it strength. The result was enormously heavy machinery. The introduction of compound, triple expansion and quadruple expansion engines is in great measure due to the production of cheap steel and the possibility of getting sufficient steam power without sinking the steamer with boilers. Comparing the *Wampanoag* with the *Charleston*, Naval Constructor Hollis has pointed out that the gain in twenty years consisted in reducing the weight of engines, boilers and coal from 46 to 36 per cent. of the displacement. The engine of the United States steamship *Powhatan*, built fifty-four years ago, weighed 508 tons, or 972 pounds per horse power.

HEAT RESISTANCE THE RECIPROCAL OF HEAT CONDUCTIVITY.

In a paper, submitted by Mr. William Kent, at the December, 1902, meeting of American Society of Mechanical Engineers, he states that during a study of heat-conducting power of various substances used for heat insulation, he has discovered that the comparison of results obtained from different experimenters would be facilitated if the results were reduced to a common basis of coefficients of heat resistance, instead of being expressed in the number of British thermal units transmitted per hour, or per day, by each square foot of surface per degree of difference of temperature of the air adjoining the two surfaces.

The use of these figures representing *resistance* instead of those representing *conductivity* is analogous to the usual practice in electrical calculations, the chief advantage being that resistances in series may be added together to obtain total resistance, while the conductance of several wires or other bodies acting in series cannot be added to obtain the total conductance. Thus, if R_1 and R_2 are the resistances of two wires arranged in series, or one after the other, their total resistance is $R_1 + R_2$. If c_1 and c_2 are the conductances of these two wires, or the reciprocal of the resistances, $= \frac{1}{R_1}, \frac{1}{R_2}$, respectively, their total conductance is not $c_1 + c_2$, but

$$1 \div \left(\frac{1}{c_1} + \frac{1}{c_2}\right)$$

The meaning of this, as applied to heat conductance, may be made clear by considering the following hypothetical case. Suppose that in testing the heat-conducting power of a certain substance, say a sheet of cardboard, we find that its conductivity, expressed in British thermal units per square foot per hour per degree of difference of temperature is 0.8, and that a sheet of felt tested in the same way gives the figure 0.4; placing a felt between two boards we obtain 0.2; two felts between three boards, 0.1143; three felts between four boards, 0.08; four felts between five boards, 0.0615.

Authorities on the subject of heat transmission generally agree that the resistance to the passage of heat through a plate consists of three separate resistances; viz., the resistances of the two surfaces and the resistance of the body of the plate, which latter is proportional to the thickness of the plate.

A complete set of experiments on the heat-resisting power of heat-insulating substances should include an investigation into the difference in surface resistance when a surface is in contact with the air and when it is in contact with another solid body. As the result of a series of such experiments the writer has prepared a table giving the coefficient of heat resistance for a great number of combinations of boards, cork, pitch, paper, etc., from which their relative values for refrigerator and cold storage construction purposes can be readily determined.

From the results of German experiments the following formula has been derived for the heat resistance of brick walls

$$C = 0.70 + 0.20\,t;$$

in which $C =$ heat resistance; $t =$ thickness of wall in inches.

In the following table, calculated by this formula, the value of C differs only slightly from that derived by the original experiments:

Thickness.	C.	K.	Thickness.	C.	K.
4-in	1.50	0.667	24-in	5.50	0.182
8-in	2.30	0.435	28-in	6.30	0.159
12-in	3.10	0.323	32-in	7.10	0.141
16-in	3.90	0.256	36-in	7.90	0.127
20-in	4.70	0.213	40-in	8.70	0.115

K in the table equals the B. T. U. transmitted per hour per square foot of surface per degree F. difference of temperature.

In conclusion the writer proposed the adoption of a standard for expressing heat resistance or tne heat insulating power of various substances as follows:

The coefficient of heat resistance of a substance is equal to unity divided by the number of British thermal units transmitted in one hour by a slab 1 square foot in area, and 1 inch thick per degree Fahrenheit of difference of temperature between the two faces of said slab, both surfaces being exposed to still air.

It should be noted that the coefficient of resistance thus defined will be approximately a constant quantity, for a given substance under certain fixed conditions, only when the difference of temperature of the air on its two sides is small—say, less than 100 degrees Fahrenheit. When the range of temperature is great, experiments on heat transmission indicate that the quantity of heat transmitted varies not directly as the difference of temperature but as the square of that difference. In this case a coefficient of resistance with a different definition may be found—viz, that obtained from the formula $a = \frac{(T-t)^2}{q}$, in which a is the coefficient, $T-t$ the range of temperature, and q the quantity of heat transmitted, in British thermal units per square foot per hour.

* * *

A REVIEW OF THE STEAM ENGINE IN 1829.*

G. L. F.

Hoene Wronski, a scientist of Polish origin, who died in Paris in 1853, published a number of works, among which was a pamphlet issued in 1829 entitled "An examination of the actual state of the steam engine, from the standpoint of mechanics and manufactures, in order to arrive at the solution of the problem presented by these machines; with a supplement giving a rigorous mathematical theory of steam engines founded on a new theory of fluids."

In this now rare work, Wronski examined the general condition of mechanical industry. The author lays down twelve principal points that stand out more prominently than others in the progressive development of the steam engine. The first lies in the actual use of steam by its expansion and condensation, as proposed by Papin but first realized by Savery in 1696. The second, though purely a negative one, is the invention of the safety valve by Papin in 1682.

The realization of the movement of the piston in a cylinder by the alternating action of the expansion and condensation of the steam, as effected by Newcomen and Cawley, constituted the third great step in the progressive development of the steam engine; a patent for the device having been issued in 1705.

The movement of a piston in a cylinder, obtained by the action of high-pressure steam and without condensation, as proposed by Leupold in 1724, was the fourth step. The saving in steam consumption obtained by the various inventions of Watt, especially the condensation outside the cylinder was the fifth step. The sixth was the regulation of the direct action of the steam upon the piston in the place of air. This was also due to Watt.

The seventh great step of advancement may be represented by the aggregation of the mechanical means used for the production of steam, for taking it into the cylinder, for governing its action, as well as for the transmission of the action of the piston to the shaft or principal motor, and to the different pieces that go to make up the moving parts of the machine. These improvements are due to a number of persons, among them Boulton and Watt.

The realization by Watt of the cut-off, by which it became possible to use the steam expansively in a part of the cylinder, was evidently the eighth fundamental step along the line of improvement of the steam engine. The ninth lies in the utilization by Hornblower of two cylinders to obtain the two distinct actions in the use of steam at the same time, namely: the constant action of its continuous pressure and the variable action due to expansion which was equally continuous.

The combination of the two-cylinder engine of Hornblower with high-pressure steam, made by A. Woolf and serving as a sort of transient machine connecting the old condensing engines with the later high-pressure engines, can surely be regarded as the tenth essential step in the evolution of the steam engine.

The determination by English and French physicists—among whom the name of Dalton is prominent— of the laws governing the phenomena presented by the action of steam can

* Translated from Bulletin de la Société des Ingénieurs Civils.

well be regarded as the eleventh step in the progress of the steam engine. Finally, the use of high-pressure steam without any condensation, as firmly established in Trevethick's engine, and which became of special value in the propulsion of carriages, was the twelfth and last step in the development of the engine of the time.

Wronski would have liked to have seen a thirteenth step—the substitution of rotary for reciprocating engines, in which he saw an enormous loss of power, due to the impulse of the piston and all of the moving parts of the machine being so frequently stopped and started. He also says, "It is generally recognized by all engineers that the total output of the best steam engines, such as they are building to-day (1829), is only one-half of the energy put into them by the steam." But surely, however great the frictional resistance of the engine might have been, it does not seem possible that it could have been equal to one-half the total energy of the steam.

Although Wronski's ideas may seem to us to be very extraordinary, we must not lose sight of the fact that they were shared by a large number of people at that time; and it is these incorrect ideas as to the economy of the reciprocating engine that led to the long-continued attempts to build an engine in which the rotation was accomplished direct from the action of the steam.

The author laid down seven conditions that should be fulfilled in the construction of a steam engine. These are as follows:

1. It should occupy the least possible amount of space; 2, in this minimum of space it should have the greatest possible amount of cylinder space for the action of steam, and should, at the same time, be of the lowest weight consistent with the requirements of strength and freedom from breakdowns; 3, its erection should be independent of the place of construction, so that it may be easily transported in sections; 4, its construction should be of the simplest character and consist of the minimum number of pieces; 5, the machine should be capable of being built at low cost and repaired at any place by ordinary machinists; 6, it should be so self-contained that its power may be rendered available without the use of wheels, cranks or other methods of transmission. As a consequence of this it should be possible to run it horizontally, vertically or in any other position in which it may be put; 7, finally, it should have a continuous and regular action and utilize the steam consumed to the utmost advantage and with the minimum losses from internal friction.

In this and what precedes there is little that is not in accord with modern practice, but the author then goes on, in a supplement, to elaborate mathematical conditions of steam-engine work, in which he shows that the principles of cylinder condensation were not known; for it was not until 1838 that Thomas gave a true solution of the phenomena of cylinder condensation due to the action of the walls of the same and the piston.

Although Wronski was disposed to believe that the ultimate improvement of the steam engine lay in the direction of the rotary machine, he did not believe at all in the possibilities of the reaction machine of the Hero type. It is quite natural that with the lack of accurate data in 1829, the author should have taken erroneous positions in regard to many points; but in his selections of the twelve great steps in the development of the steam engine he did pick out the most important features that had been brought out up to that time, while his essential conditions for a successful engine might almost be adopted by the designers of the present day.

* * *

The Bureau of Statistics has issued a summary of the growth of the manufacturing industries of the country since 1870 and of the progress in agriculture, including products for home and foreign consumption. Since 1870 the population has increased practically 100 per cent. Agricultural production has increased 92 per cent., or almost the same rate as the increase in population, while the production of manufactures has increased 209 per cent. Of the agricultural products we now export 132 per cent. more than in 1870 and the exportation of manufactures has increased 538 per cent. Comparing figures with 1850 the production of manufactured products is now 13 times as great, while the population has increased but a little over three times in that period.

STEEL CASTINGS.*

SPECIFICATIONS, USES, PROCESSES, RELIABILITY.

The raw materials that usually enter into the making of steel castings are steel scrap, pig iron and iron ore. The scrap consists of the crop ends of plates, shapes and forgings and the borings and turnings from the machine shop. The bulk of the furnace charge is scrap, the proportion of pig being about one-fifth at the beginning of a run—that is, immediately after a furnace has been rebuilt—and increasing up to nearly three-tenths at the end of the run, when the furnace lining and brick work generally are getting so slagged and burnt out as to require renewal. These proportions are of acid steel, basic steel using larger quantities of pig. The amount of iron in the ore is a secondary consideration, the ore being used chiefly for its oxygen, which comes into play in oxidizing the metalloids carbon, silicon, sulphur, phosphorus. The proportion of ore required in a charge depends upon the character of the other ingredients; ordinarily in an acid furnace from one to two, or two and a half per cent. would be used. There have been cases where scrap could not be procured, and the charge has been made up, of necessity, entirely of pig and ore, over three-fifths being pig. Hematite ore is the variety most used, and is obtained in large quantities in the Lake Superior region in this country and Canada; much of it is also imported from Cuba, Spain and elsewhere.

The amount of carbon combined with iron makes one difference between wrought iron and steel and between steel and cast iron. A second and equally important difference is the method of manufacture and the resulting properties and character. Wrought iron is soft and fibrous; cast iron is hard, crystalline and brittle; steel comes in anywhere between.

Basic steel is used in making castings, but not so generally as the acid product. Cheaper raw materials can be used in making basic steel, and phosphorus, the element chiefly objected to, can be nearly eliminated. It is more expensive than acid steel, however, and fewer heats per run of furnace can be turned out. With acid steel the number of heats will reach nearly three for each twenty-four hours, depending upon the size of furnace and character and quantity of work.

Open Hearth Furnaces.

These raw materials are melted down in a reverberatory furnace with gaseous fuel distilled from special bituminous coals in gas producers. Under each end of the furnace is a pair of regenerators—one for air, one for gas—which communicate with the furnace on one side and on the other with flues leading to the sources of supply of gas and air to the chimney. Reversing valves are located at the point where the flues meet, and about every twenty minutes, while the furnace is in operation, the valves are shifted and the currents of air and gas turned in the opposite direction. Each regenerator is nearly filled with fire brick built up in such an open checkerboard manner that the air and gas find their way among and through them, absorbing heat from them on their way to the hearth, and, when spent, giving up heat to those in the opposite regenerators.

With this type of furnace a temperature of 4,000 degrees Fahrenheit can be attained, but as the supply of gas and air is at all times under control the temperature can be made whatsoever may be desired. The process in the furnace will be acid or basic according to the character of the furnace lining—basic linings and additions being used in one case and an acid lining, such as ordinary fire brick and fire clay, in the other.

Specifications.

Castings requiring annealing are placed in annealing furnaces, where they are gradually and uniformly heated up to temperatures depending upon the composition of the metal and varying between 1,200 and 1,600 degrees Fahrenheit, kept soaking at the maximum temperature for a time determined by their size, and allowed gradually to cool without exposure to the air. When cold the coupons are detached and the necessary test specimens cut from them and machined accurately to required size. These specimens are then broken or bent in an approved testing machine according to the specifications

* Abstract from Journal of the American Society of Naval Engineers, February, 1903.

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PROPERTIES OF SATURATED STEAM.

Absolute Pressure.	Gage Pressure.	Temperature F.	Weight in Pounds per Cubic Foot of Steam.	Volume in Cubic Feet of One Pound of Steam.	Total Heat above 32° F. In the Water, Heat Units.	Total Heat above 32° F. In the Steam, Heat Units.	Latent Heat, Heat Units.
1	–27.9	102.1	.003	334.23	70.09	1113.1	1043.0
5	–19.7	162.3	.014	72.50	130.7	1131.4	1000.7
10	–9.6	193.2	.026	37.80	161.9	1140.9	979.0
14.7	0.	212.0	.038	26.36	180.9	1146.6	965.7
15	.3	213.0	.039	25.87	181.9	1146.9	965.0
20	5.3	227.9	.050	19.72	197.0	1151.5	954.4
25	10.3	240.0	.063	15.99	209.3	1155.1	945.8
30	15.3	250.2	.074	13.48	219.7	1158.3	938.9
35	20.3	259.2	.086	11.66	228.8	1161.0	932.2
40	25.3	267.1	.097	10.28	236.9	1163.4	926.5
45	30.3	274.3	.109	9.21	244.3	1165.6	921.3
50	35.3	280.9	.120	8.34	251.0	1167.6	916.6
55	40.3	286.9	.131	7.63	257.2	1169.4	912.3
60	45.3	292.5	.142	7.03	262.9	1171.2	908.2
65	50.3	297.8	.153	6.53	268.3	1172.8	904.5
70	55.3	302.7	.164	6.09	273.4	1174.3	900.9
75	60.3	307.4	.175	5.71	278.2	1175.7	897.5
80	65.3	311.8	.186	5.37	282.7	1177.0	894.3
85	70.3	316.0	.197	5.07	287.0	1178.3	891.3
90	75.3	320.0	.208	4.81	291.2	1179.6	888.4
95	80.3	323.9	.219	4.57	295.1	1180.7	885.6
100	85.3	327.6	.230	4.36	298.9	1181.8	882.9
110	95.3	334.5	.251	3.98	306.1	1184.0	877.9
120	105.3	341.0	.272	3.67	312.8	1185.9	873.2
130	115.3	347.1	.294	3.41	319.1	1187.8	868.7
140	125.3	352.8	.315	3.18	325.0	1189.5	864.6
150	135.3	358.2	.336	2.98	330.6	1191.2	860.6
160	145.3	363.3	.357	2.80	335.9	1192.7	856.9

PUNCH PUNCH

CREASE HERE.

PROPERTIES OF SATURATED STEAM (Continued).

Absolute Pressure.	Gage Pressure.	Temperature F.	Weight in Pounds per Cubic Foot of Steam.	Volume in Cubic Feet of One Pound of Steam.	Total Heat above 32° F. In the Water, Heat Units.	Total Heat above 32° F. In the Steam, Heat Units.	Latent Heat, Heat Units.
170	155.3	368.2	.378	2.65	340.9	1194.2	853.3
180	165.3	372.8	.398	2.51	345.8	1195.7	849.9
190	175.3	377.3	.419	2.39	350.4	1197.0	846.6
200	185.3	381.6	.440	2.27	354.9	1198.3	843.4
210	195.3	385.7	.461	2.17	359.2	1199.6	840.4
220	205.3	389.7	.485	2.06	362.2	1200.8	838.6
230	215.3	393.6	.506	1.98	366.2	1202.0	835.8
240	225.3	397.3	.527	1.90	370.0	1203.1	833.1
250	235.3	400.9	.548	1.83	373.8	1204.2	830.5
260	245.3	404.4	.569	1.76	377.4	1205.3	827.9
270	255.3	407.8	.589	1.70	380.9	1206.3	825.4
280	265.3	411.0	.610	1.64	384.3	1207.3	823.0
290	275.3	414.2	.630	1.585	387.7	1208.3	820.6
300	285.3	417.4	.651	1.535	390.9	1209.2	818.3
350	335.3	432.0	.755	1.325	406.3	1213.7	807.5
400	385.3	444.9	.857	1.167	419.8	1217.7	797.9
450	435.3	456.6	.959	1.042	432.2	1221.3	789.1
500	485.3	467.4	1.062	.942	443.5	1224.5	781.0
550	535.3	477.5	1.164	.859	454.1	1227.6	773.5
600	585.3	486.9	1.266	.790	464.2	1230.5	766.3
650	635.3	495.7	1.368	.731	473.6	1233.2	759.6
700	685.3	504.1	1.470	.680	482.4	1235.7	753.3
750	735.3	512.1	1.572	.636	490.9	1238.0	747.2
800	785.3	519.6	1.674	.597	498.9	1240.3	741.4
850	835.3	526.8	1.776	.563	506.7	1242.5	735.8
900	885.3	533.7	1.878	.532	514.0	1244.7	730.6
950	935.3	540.3	1.980	.505	521.3	1246.7	725.4
1000	985.3	546.8	2.082	.480	528.3	1248.7	720.3

PUNCH PUNCH

6 x 9 DATA SHEETS.

In ... data or other information that shall be accepted for one of these data sheets.

These data sheets are intended to be cut into four sections, 6 x 9 inches in size, as indicated by the straight lines. They may then be bound into note book form for convenient reference by means of staples inserted in holes punched at the points indicated.

160	145.3	363.3	.357	2.80	335.9	1192.7	856.9

PUNCH

PUNCH

CREASE HERE.

Weight of Water per Cubic Foot and Heat Units in Water between 32° and 212° F.

Temperature, Degrees F.	Weight in pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.	Temperature, Degrees F.	Weight in Pounds per Cubic Foot.	Heat Units.
32	62.42	0.00	78	62.25	46.03	124	61.67	92.17	170	60.77	138.45
34	62.42	2.00	80	62.23	48.04	126	61.63	94.17	172	60.73	140.47
36	62.42	4.00	82	62.21	50.04	128	61.60	96.18	174	60.68	142.49
38	62.42	6.00	84	62.19	52.04	130	61.56	98.19	176	60.64	144.51
40	62.42	8.00	86	62.17	54.05	132	61.52	100.20	178	60.59	146.52
42	62.42	10.00	88	62.15	56.05	134	61.49	102.21	180	60.55	148.54
44	62.42	12.00	90	62.13	58.06	136	61.45	104.22	182	60.50	150.56
46	62.42	14.00	92	62.11	60.06	138	61.41	106.23	184	60.46	152.58
48	62.41	16.00	94	62.09	62.06	140	61.37	108.25	186	60.41	154.60
50	62.41	18.00	96	62.07	64.07	142	61.34	110.26	188	60.37	156.62
52	62.40	20.00	98	62.05	66.07	144	61.30	112.27	190	60.32	158.64
54	62.40	22.01	100	62.02	68.08	146	61.26	114.28	192	60.27	160.67
56	62.39	24.01	102	62.00	70.09	148	61.22	116.29	194	60.22	162.69
58	62.38	26.01	104	61.97	72.09	150	61.18	118.31	196	60.17	164.71
60	62.37	28.01	106	61.95	74.10	152	61.14	120.32	198	60.12	166.73
62	62.36	30.01	108	61.92	76.10	154	61.10	122.33	200	60.07	168.75
64	62.35	32.01	110	61.89	78.11	156	61.06	124.35	202	60.02	170.78
66	62.34	34.02	112	61.86	80.12	158	61.02	126.36	204	59.97	172.80
68	62.33	36.02	114	61.83	82.13	160	60.98	128.37	206	59.92	174.83
70	62.31	38.02	116	61.80	84.13	162	60.94	130.39	208	59.87	176.85
72	62.30	40.02	118	61.77	86.14	164	60.90	132.41	210	59.82	178.87
74	62.28	42.03	120	61.74	88.15	166	60.85	134.42	212	59.76	180.90
76	62.27	44.03	122	61.70	90.16	168	60.81	136.44			

1000	985.3	546.8	2.082	.480	528.3	1248.7	720.3

PUNCH

PUNCH

CREASE HERE.

COMPARISON OF THERMOMETER SCALES.

Centigrade.	Reaumur.	Fahrenheit.	Centigrade.	Reaumur.	Fahrenheit.	Centigrade.	Reaumur.	Fahrenheit.
−30	−24.0	−22.0	14	11.2	57.2	58	46.4	136.4
−28	−22.4	−18.4	16	12.8	60.8	60	48.0	140.0
−26	−20.8	−14.8	18	14.4	64.4	62	49.6	143.6
−24	−19.2	−11.2	20	16.0	68.0	64	51.2	147.2
−22	−17.6	−7.6	22	17.6	71.6	66	52.8	150.8
−20	−16.0	−4.0	24	19.2	75.2	68	54.4	154.4
−18	−14.4	−0.4	26	20.8	78.8	70	56.0	158.0
−16	−12.8	3.2	28	22.4	82.4	72	57.6	161.6
−14	−11.2	6.8	30	24.0	86.0	74	59.2	165.2
−12	−9.6	10.4	32	25.6	89.6	76	60.8	168.8
−10	−8.0	14.0	34	27.2	93.2	78	62.4	172.4
−8	−6.4	17.6	36	28.8	96.8	80	64.0	176.0
−6	−4.8	21.2	38	30.4	100.4	82	65.6	179.6
−4	−3.2	24.8	40	32.0	104.0	84	67.2	183.2
−2	−1.6	28.4	42	33.6	107.6	86	68.8	186.8
0	0.0	32.0	44	35.2	111.2	88	70.4	190.4
2	1.6	35.6	46	36.8	114.8	90	72.0	194.0
4	3.2	39.2	48	38.4	118.4	92	73.6	197.6
6	4.8	42.8	50	40.0	122.0	94	75.2	201.2
8	6.4	46.4	52	41.6	125.6	96	76.8	204.8
10	8.0	50.0	54	43.2	129.2	98	78.4	208.4
12	9.6	53.6	56	44.8	132.8	100	80.0	212.0

prescribed. The latest specifications of the Bureau of Steam Engineering are here given in full:

(1) The physical and chemical characteristics of steel castings must be in accordance with the following data, to meet the requirement of the Bureau of Steam Engineering of the Navy Department: Class A castings, annealed; tensile strength 80,000; elastic limit 35,000; per cent. elongation in two inches, 15; reduction of area, per cent., 20; maximum phosphorus, .06; cold bend, ½-inch radius, through 90 degrees. Class B castings, annealed: Values of above specification change to the following, taken in order: 65,000; 30,000; 18; 25; .06; through 120 degrees. There is also a third class, called Class C, which will ordinarily be subject to surface inspection only at the building yard. They will not be tested unless there are reasons to doubt they are of a quality suitable for the purpose for which they are intended. The inspector will select a sufficient number of castings and have them crushed, bent or broken and note their behavior and the appearance of the fracture.

(2) *Kind of material.*—Steel for castings may be made by the crucible, open-hearth, Bessemer, Tropenas or any other process approved by the Bureau of Steam Engineering. The material must be of uniform quality throughout. In case of doubt on this point, the inspector will have drillings for complete analysis, taken from the surface and from the center of the thickest parts. In all cases analyses will be made for phosphorus, and no casting shall contain more than six one-hundredths of 1 per cent.

(3) *Treatment.*—All castings, except those of Class C, shall be annealed, unless otherwise directed. If castings are subjected to any special treatment, the inspector will make such additional tests as he may deem necessary to see that the treatment has left the material of uniform character throughout. In case the results obtained by the first tests do not conform to the specifications, the manufacturer may re-treat the castings and submit additional pieces for test.

(4) *Surface and other defects.*—All castings shall be thoroughly cleaned before they are presented for inspection. They shall be sound, free from brittleness, injurious roughness, sponginess, pitting, porosity, shrinkage and other cracks, cavities, foreign substance, and all other injurious defects. Particular search shall be made at the points where the heads or risers join the castings, as unsoundness at such points is likely to extend into the castings.

(5) *Test pieces.*—Sound test pieces shall be taken in sufficient number to thoroughly exhibit the character of the metal in the entire piece from each of the following castings, viz.: Shaft struts or brackets, main cylinder or valve-chest liners, main pistons and followers, eccentric, reversing and rock shaft arms, crossheads, bedplates, columns of main engines and main air pumps, shaft couplings, and all large castings weighing over 200 pounds. All other castings may be tested by lots, as follows: A lot shall consist of all castings from the same heat, annealed in the same furnace charge. From each lot two or more tensile and one or more bending test pieces shall be taken, and the lot passed or rejected on the results shown by the tests. The test pieces may, at the discretion of the inspector, be cut either from coupons to be molded and attached to some portion of the casting, or else from sinking heads, in cases where such heads of sufficient size are employed. Coupons are to be attached so as not to interfere with the successful making of the casting, but at the same time to show the quality of the material. In the case of castings tested by lots, and if the manufacturer so desires, the test pieces may be taken from the body of a casting selected by the inspector from the lot. In no case shall the coupons be detached from their castings before they are stamped by the inspector. In special cases where the attachment of a coupon would be liable to injure the casting, the coupon may be cast with small runners to the gate, or separately in the same flask, so that they may be easily identified when the casting is knocked out of the sand. In all such cases the sanction of the inspector must first be obtained.

(6) *Percussion test.*—Large castings shall be suspended and hammered all over with a hammer weighing not less than 7½ pounds. No cracks, flaws, defect or weakness shall appear after such treatment.

Uses of Steel Castings.

Steel castings are used for cylinder and valve-chest covers, for pistons, crosshead guides and slippers, bearing caps and shoes, eccentric sheaves and straps, rocker arms, thrust-bearing boxes and collars, bedplates and housings and other parts of main and auxiliary machinery; for boiler headers, manifolds, drum ends, dry pipes, manhole and handhole doors and other parts of boilers; anchors, anchor davits, hawse pipes, chocks, mooring and towing bitts, stems, stern posts, stern tubes, shaft brackets, manhole covers and other parts of ships' hulls, gun mounts, parts of dynamos and motors. Their use in ship construction and aboard ship is thus seen to be a large and important matter.

The cast-steel girders for the 16-inch army gun carriage, the gun now being tested at the Sandy Hook proving grounds, measure each 33 feet by 17 feet by 5 feet, and will weigh about 100,000 pounds apiece; the carriage presents problems in transportation from the foundry to the arsenal at Watervliet on account of size and weight. A large casting turned out in the eastern part of Pennsylvania for a hydraulic forging press to be set up in the western part of the same State required about 320,000 pounds of metal from six open-hearth furnaces to pour it.

Cire Perdu Process.

Some five hundred years ago, more or less, a method of casting bronze statuary in which wax played a chief part was evolved and practiced. A mass of clay was built up into a shape roughly resembling the desired figure, and this was coated heavily with the wax preparation. This wax was then cut and carved into the finished shape, and, in its turn, covered with a heavy layer of clay. By sufficiently heating the mass the wax was melted out, leaving a perfect mold and core, and the molten bronze was then run into it and the desired statue thus produced. To-day there is a patented process in use, for turning out a large number of steel castings of the same size and shape, which makes use of this idea. A master mold of cast iron is made, and a number of patterns are cast in this of an alloy fusible at low temperature, such as a mixture of antimony and bismuth. The damp molding sand is thrown at and around these alloy patterns by pneumatic apparatus, and the molds, thus quickly and cheaply made, are then dried in the usual way. The heat of the drying ovens melts the patterns, and the fluid alloy runs out at the bottom of the mold and is caught to be used again. The bottom of the mold being closed, fluid steel is poured in, and when the castings are shaken out very little cleaning is required to present them ready for service or for the machine shop.

Are Steel Castings Reliable?

A forged or rolled object is worked down from a billet which previously was hammered or pressed down from an ingot or part of an ingot, and during these stages of manufacture the metal is more or less thoroughly squeezed and pressed and caused to flow upon itself in various directions, and all parts, inside and out, receive some heat and power treatment, so that the impression grows in the minds of those who manipulate the forgings and of those who witness the manipulation that the accepted objects are free from weakening defects; the assurance of their trustworthiness is positive.

In the case of castings no such certainty or confidence is created. A steel casting may come out of the final cleaning process a thing of beauty, the physical and chemical tests may gladden the heart, the required machining may show up no flaws, yet the fear will not down that below its surface somewhere a treacherous cavity or other weakness may some day get in its deadly work—a day when most dependence is necessarily placed upon the casting, when most damage may result from its failure to do its duty. However, the industry is steadily improving; all things human, especially all things American, are marching forward, and in time this fear will disappear, and eventually as much reliance be placed in a steel casting as in a hammered, pressed, rolled or drawn object, but the question may now be asked, Is that time in sight?

* * *

The Treasury Bureau of Statistics report that for the first three months of 1903 the Beaumont oil fields shipped 16,428 cars loaded with petroleum, or 2,791,483 barrels.

BLOWING ENGINE FOR THE SHARON STEEL CO.

The large blowing engine shown in the accompanying half-tones and line cuts, Figs. 1 to 5, is one of a lot of six being built by Mackintosh, Hemphill & Co., Pittsburg, Pa., for the Sharon Steel Co., Sharon, Pa., one of the constituent companies of the United States Steel Corporation. It is a 30-inch and 60-inch and 60 x 72-inch Corliss horizontal, cross-compound, condensing engine, having a capacity of 30,000 cubic feet of free air per minute at the normal blast pressure of 18 pounds and a steam pressure of 150 pounds per square inch, running at a speed of 60 revolutions per minute. The blast pressure may be increased, however, to 25 pounds in cases of emergency, and the speed may be varied up to a maximum of about 70 turns per minute.

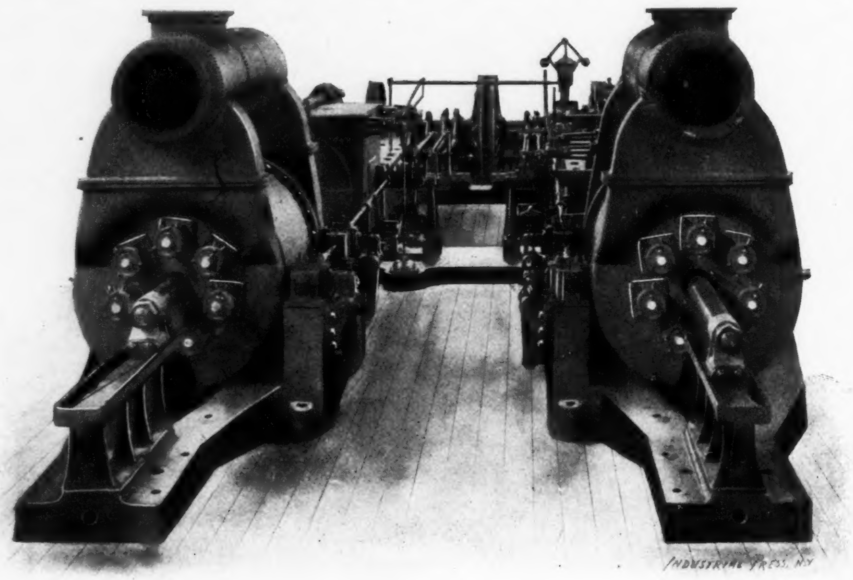


Fig. 1. End View of Blowing Cylinders showing Tail-rod and Guides and Caps to Dash-pots of Outlet Valves.

The general design of this blowing engine, is typical of the rugged strength and massiveness characterizing the rolling mill machinery built by this firm. Mackintosh, Hemphill & Co., we may mention in this connection, is one of the oldest machinery building and founding concerns in Pittsburg, having been originally the famous Fort Pitt Foundry which was established in 1810. A brief account of the early history of this foundry was given in the April, 1901, issue. To revert to the matter of design it is well understood that reliability of this class of machinery, which means the ability to run week in and week out with a minimum of stoppages for repairs, is of first importance and is a condition absolutely necessary in the economical operation of a blast furnace. A serious breakdown of a blowing engine may easily mean a loss of thousands of dollars in loss of product and damage to the furnaces. This being the case we shall look at the design of this engine with renewed interest since it is a foregone conclusion that it is one that is known to be of proven merit.

In the elevation, Fig. 3, the construction of the frame may be profitably studied as a problem in design. This part of a machine 77 feet 6 inches long, which must be rigidly connected in all parts, yet free to expand and contract with variations of temperature in the component parts, is a most troublesome one to the designer of this class of machinery. In fact it may be safely stated that in all probability expansion and contraction stresses have been responsible for more failures of rolling mill engines and blowing engines in the past than any other cause. In this design the front part of the frame carrying the main bearings, is connected to each blast cylinder by means of a 7-inch tie-rod at the top, and the extended base of the blast cylinder, at the bottom. The steam cylinders are connected to the front casting so as to be perfectly free to expand and contract longitudinally without affecting the integrity of the frame in any degree.

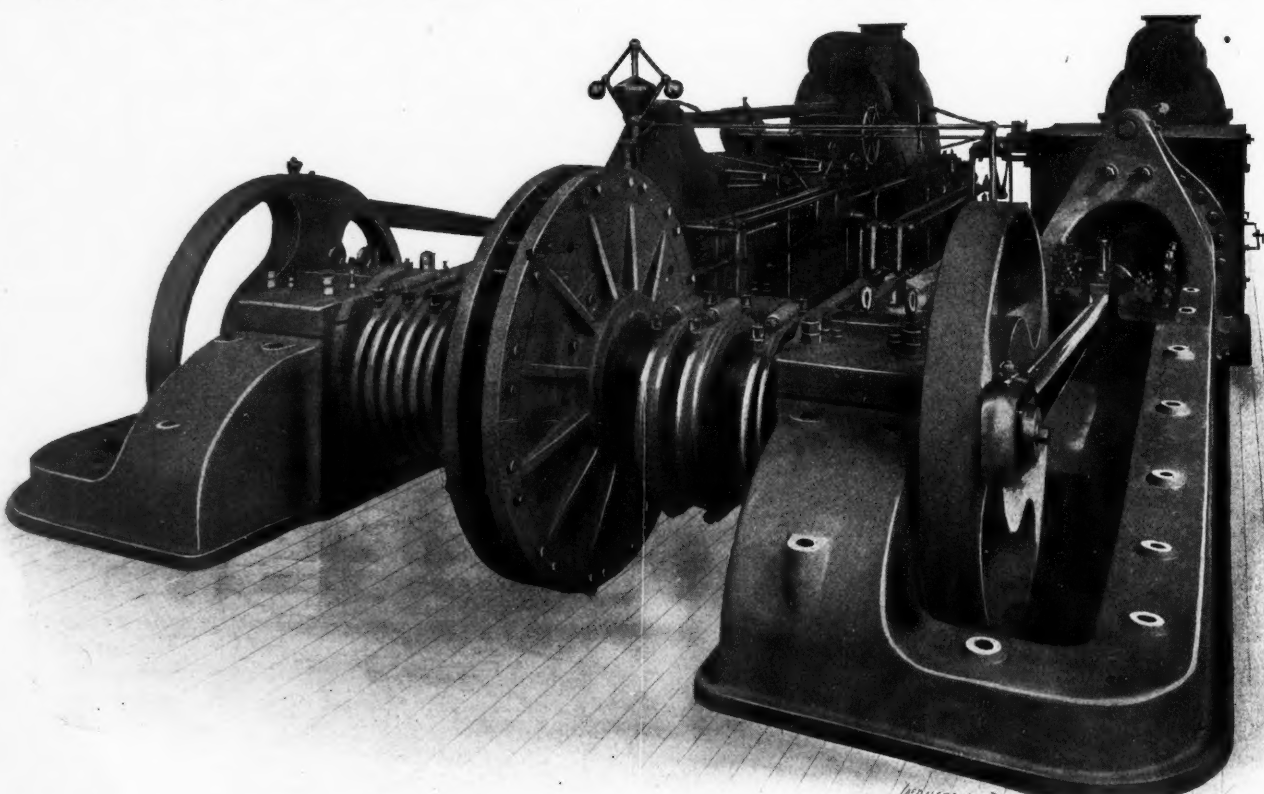


Fig. 2. Blowing Engine built by Mackintosh, Hemphill & Co. for Sharon Steel Co. Capacity, 30,000 cubic feet of Free Air per minute.

Six separately adjustable eccentrics are provided for operating the Corliss valve motion and the inlet valves of the compressor cylinders. In the plan view it will be observed that the connections between the eccentrics and the steam valves are uniformly in a straight line, which does away

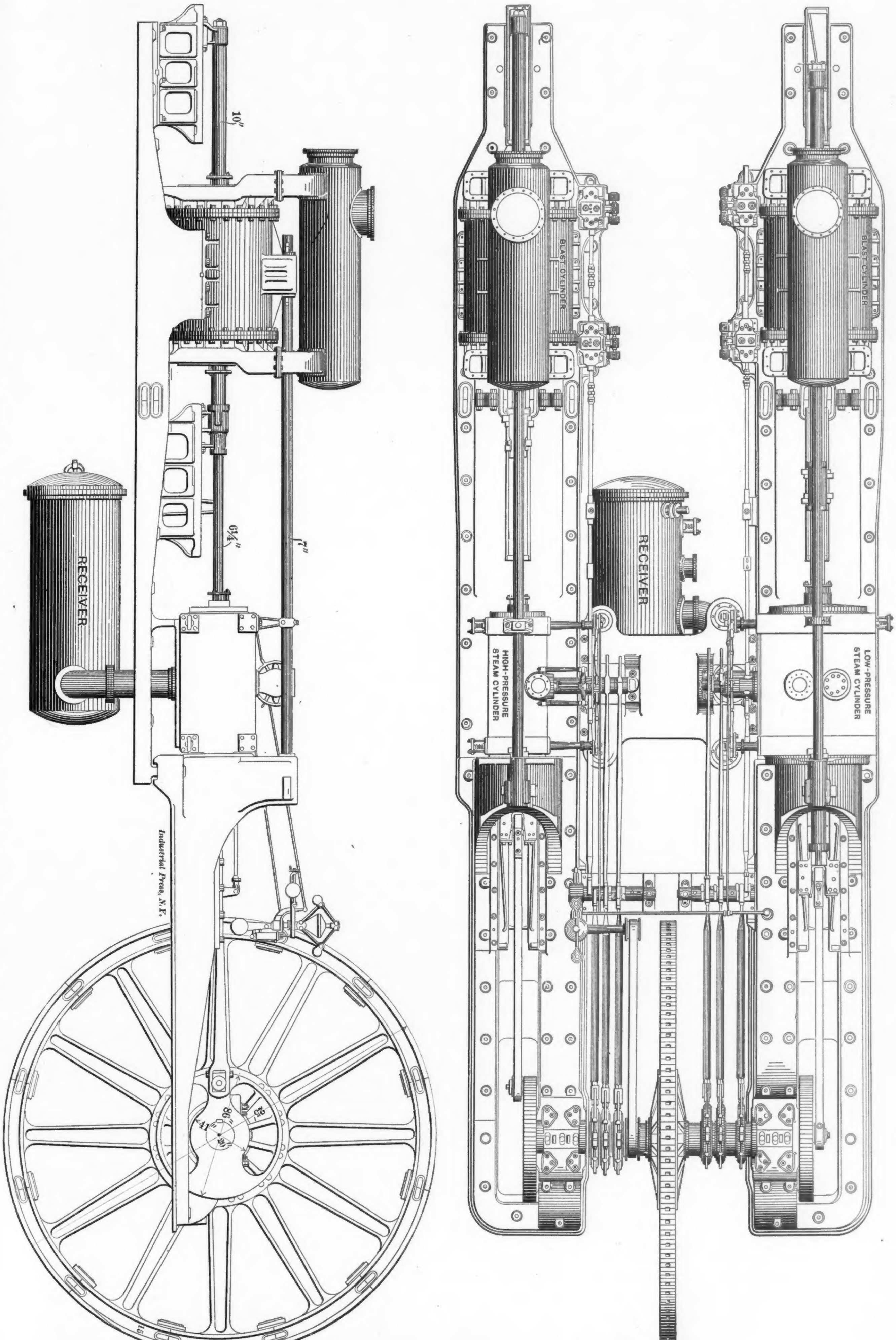


Fig. 3. Plan and Side Elevation of Blowing Engine. Total Length over all, 77 feet 6 inches. Cross-compound Condensing Engine with Corliss Double Eccentric Valve Gear.

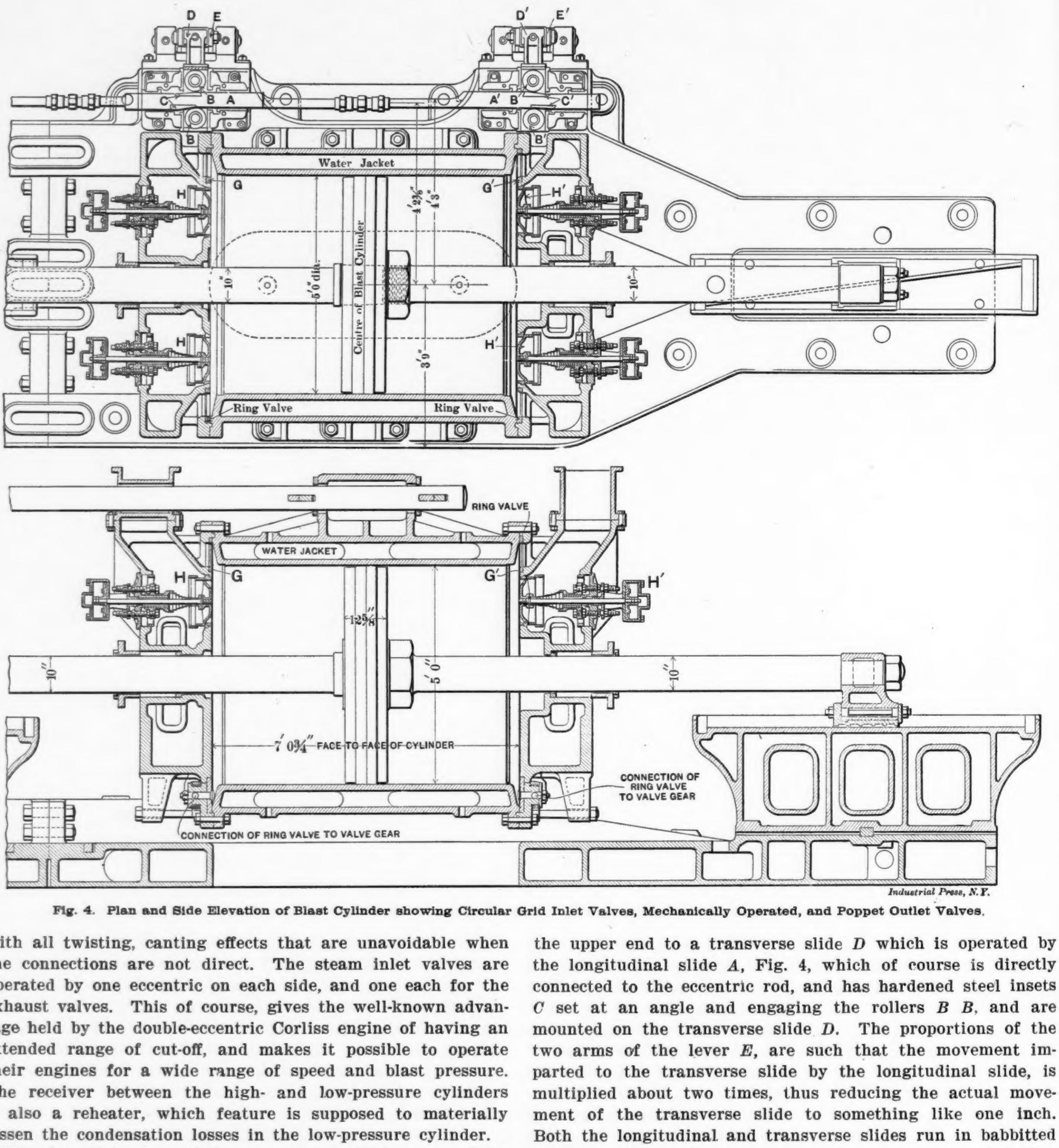


Fig. 4. Plan and Side Elevation of Blast Cylinder showing Circular Grid Inlet Valves, Mechanically Operated, and Poppet Outlet Valves.

with all twisting, canting effects that are unavoidable when the connections are not direct. The steam inlet valves are operated by one eccentric on each side, and one each for the exhaust valves. This of course, gives the well-known advantage held by the double-eccentric Corliss engine of having an extended range of cut-off, and makes it possible to operate their engines for a wide range of speed and blast pressure. The receiver between the high- and low-pressure cylinders is also a reheater, which feature is supposed to materially lessen the condensation losses in the low-pressure cylinder.

The air outlet valves of the compressor cylinders, are of the single poppet type, 12 inches in diameter, and there are seven in each cylinder head arranged in a circle close to the piston rod. They are held to their seats by heavy volute springs, and are provided with dash-pots to prevent slamming when forced open by the pressure developed in the cylinder. The inlet valves, which are mechanically operated as already stated, are of the circular grid type, 5 feet 5½ inches mean diameter, and are set between the heads and cylinders surrounding the space occupied by the poppet outlet valves. The inlet valves are oscillated in a plane at right angles to the cylinder axes which makes their movement by a simple reliable mechanism, an interesting feature. The construction of the compressor cylinders and of the air inlet valve motion, is shown in the plan and elevation sections, Fig. 4. A cross section, Fig. 5, gives further details.

The ports covered by the circular grid valve are 1 11-16 inch, and the bridges 2 3-16 inches mean width. The mean travel, that is, the travel on a radius equal to that from the center of the valve to the center of the valve motion connecting-rod pin, a distance of 2 feet 8¾ inches, is 1.98 inch. This movement is effected through the valve connecting-rod *F*, and the lever *E*, Fig. 5. The lever *E* is pivoted and is connected at the upper end to a transverse slide *D* which is operated by the longitudinal slide *A*, Fig. 4, which of course is directly connected to the eccentric rod, and has hardened steel insets *C* set at an angle and engaging the rollers *B B*, and are mounted on the transverse slide *D*. The proportions of the two arms of the lever *E*, are such that the movement imparted to the transverse slide by the longitudinal slide, is multiplied about two times, thus reducing the actual movement of the transverse slide to something like one inch. Both the longitudinal and transverse slides run in babbitted bearings. The rollers *B B* are of large size, being 6 inches diameter and 4 inches thick.

It is scarcely necessary to point out that the air cylinder piston is carried free of the bottom of the cylinder by the tail rod, which in turn is borne up by slippers running on guides. This feature is of great importance in the operation of a compressor, as it saves great wear on the cylinder and much loss of power by friction. The outside bearings are obviously in a position to be much more effectively lubricated than the interior of the cylinder. The piston rods are secured in the middle slipper by double keys. It will also be noted that the blast cylinders are water-jacketed which we believe has not been a common practice hitherto. The clearance is reduced to 1¼ per cent.

The flywheel is of the built-up type, 25 feet diameter and weighing 40 tons. The rim sections are connected together by shrunk links on the sides and inner circle, thus giving three links for each joint. The crank disks are steel castings 86 inches diameter.

* * *

A summer school for artisans is to open at the University of Wisconsin, Madison, July 6th. Practical courses in mechanics and engineering, and shop work, are to be given.

PISTONS AND PACKING RINGS.—5.

"SNAP RINGS."

J. H. DUNBAR.

The snap ring made of cast iron is the most popular packing for piston heads just now, and bids fair to continue to be so for a long time to come. This is due principally, to its cheapness, ease of renewal, etc., and a widespread sentiment that it is "good enough." While some find fault with it on account of its liability to break, or because of an occasional one which has been badly proportioned, poorly made, or which for some other reason has not had a chance to be satisfactory, the snap ring nevertheless is holding its own against the field.

Packing rings are seldom made of any other material than cast iron, but their relative proportions vary largely. There are, however, but two types of snap rings, viz., the one made of uniform section, and the eccentric. These are shown in Figs. 1 and 2, respectively. Each is made about one per cent. larger than the cylinder, and has a corresponding amount cut out of its circumference, so as to let it slide freely in the cylinder, when the ring is sprung into it. Their thickness and radial dimension are great enough to allow them to be sprung over the follower, or flanges of the piston, and "snap" into their grooves, without too much danger of breaking in the operation. About three per cent. of their diameter is a practical thickness for Fig. 1, making a ring for a 20-inch cylinder ⅝-inch thick, and 20 3-16 inches outside diameter. Fig. 2 has the same diameter, but ¾ and ⅜ at its thick and thin sides respectively.

It will be seen that rings of uniform section, when turned larger than the cylinder, and cut and sprung into it, will bear only on two opposite lines, top and bottom, as shown in Fig. 3. It has been believed that rings like this will soon wear a cylinder oblong; hence many remedies have been proposed for the ailment. The eccentric ring has been mentioned as a panacea for the complaint, and when made according to Prof. S. W. Robinson's formula, it is theoretically perfect in all respects. It is shown in Fig. 4, and is laid out from the figures in the following table, which are copied from Unwin's "Elements of Machine Design."

10 degrees from the top, thickness is .197 times that at bottom.
20 degrees from the top, thickness is .311 times that at bottom.
40 degrees from the top, thickness is .489 times that at bottom.
60 degrees from the top, thickness is .630 times that at bottom.
80 degrees from the top, thickness is .745 times that at bottom.
100 degrees from the top, thickness is .837 times that at bottom.
120 degrees from the top, thickness is .908 times that at bottom.
140 degrees from the top, thickness is .960 times that at bottom.
160 degrees from the top, thickness is .990 times that at bottom.
180 degrees from the top, thickness is 1.000 times that at bottom.

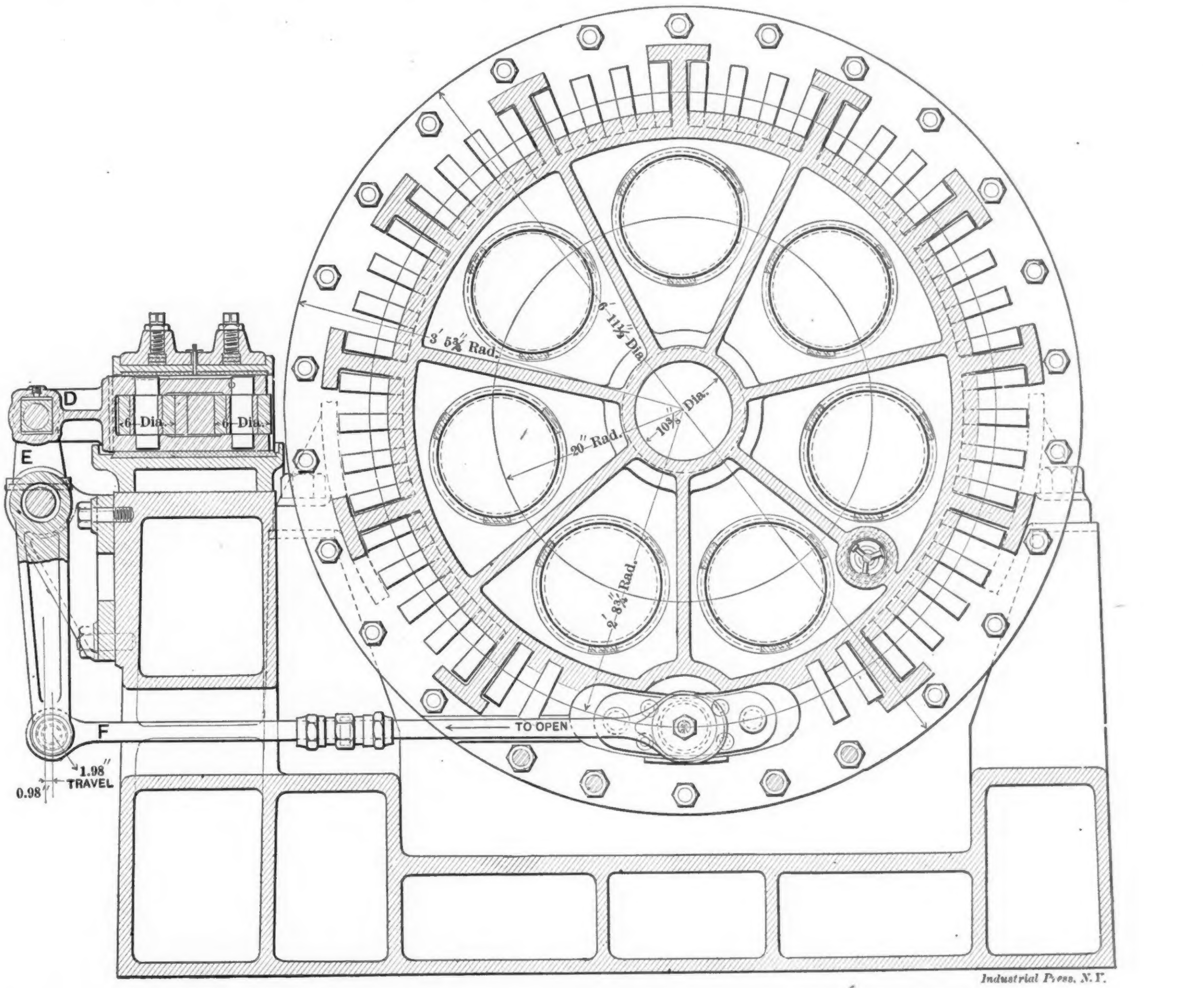
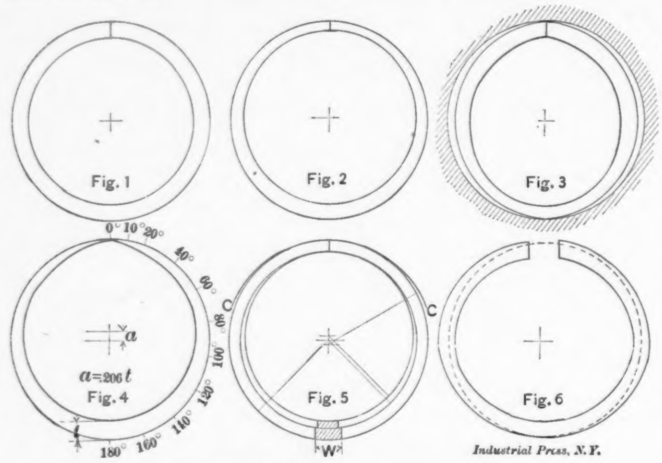


Fig. 5. End View of Circular Grid Inlet Valve and Operating Mechanism. (See Opposite Page.)

In designing a ring from this table, first draw a circle to represent the diameter that the ring is to be turned and decide upon the bottom, or thickest part, say ¾ inch for a 20-inch ring. Now space the circumference as in Fig. 3, then beginning with nothing at the top, make the thickness at 10 degrees, $.197 \times ¾ = .197 \times .75 = .14775$ inch, say 5-32ds, and so on around the ring. It will be found that if we set the needle point of our dividers above the center of the outside of the ring (.206 times the thickness of the ring at the bottom), the other leg of the dividers may be set to sweep through two-thirds of the points that have been made from the table, so there is no need of calculating further down than 80 degrees. In making the ring in the shop, it will be necessary to square up the points, till the ring will close enough to go into the cylinder.

In practice, this ring would be very objectionable, owing to the liability of the thin ends to break off and to wedge in between the follower and cylinder. Or, if they do not break, the side wear of the grooves and ring at its thin part would

be excessive. To obviate this trouble, the rings are turned regularly eccentric, as in Fig. 5, and the ends eased off with a file, on each side of the joint, till they fit the cylinder. After fitting a number of rings in this way, one of the boys suggested to do the easing act in the lathe, by shifting the casting in the chuck, and taking a light cut off the thin part, as shown in the line *C C*, after the rings had been bored and turned. This method very materially lessened the amount of filing required to make the rings fit, and in some cases was good enough, without touching with a file, a few rubs through the cylinder being all they needed. In order to secure uniform groove wear, rings of this kind are now usually recessed on each side, as shown in the cross section at the bottom of the ring in Fig. 5.



Types of Cast Iron Snap Rings.

I found that for pistons, say 15 inches and under, the eccentric type of ring does not give enough groove surface to insure the best results, especially if the engine runs at a high rotative speed. In larger engines, after the piston is worn down, the same fault is found. Take our 20-inch piston, for example, which we will suppose has worn till it is ¼ inch smaller than the cylinder. Now, if the piston rides on the bottom of the cylinder the packing ring will only have ⅛ inch of a hold in the groove, and when the ring wears ⅛ inch, something is going to happen. If the rings are made as in Fig. 2, and doweled to the piston, so that their joints are kept near the bottom of the cylinder, the ring contact with the piston is nearly uniform and the packing O. K. More groove area would of course be better, and I decided to make a ring having a uniform cross section, which should have as many of the eccentric ring's virtues and as few of its faults as possible. This is accomplished by making a ring that is initially distorted, as in Fig. 6. The theory of this method is, that if a ring of uniform cross section, the diameter of the cylinder, is cut through at one side, and then expanded by internal forces, until it is open at the joint one per cent. of its circumference, it then presents a shape to make others by.

I have made these rings, by first making a pattern ring as just described, and then having rings cast from it, the castings being finished in a special grinding machine. Not enough advantage was found in their use to justify a claim that they filled a long-felt want, although they fit a round cylinder to perfection. Round rings of uniform section that are "flattened" at the joint, as in Fig. 5, when put into service, immediately adjust themselves to their surroundings; so that when worn out they still have a uniform thickness, or at least, as nearly so as when new, showing an equal amount of wear on all parts of their circumference.

New rings, proportioned as above, have a pressure against the cylinder of about five pounds per square inch. We can imagine how insignificant a little lack of uniform spring pressure will be when we consider that the ring is subject to an internal steam pressure of a hundred pounds or more to the square inch, to set it out to the cylinder. Even if a ring touches the cylinder only in spots at the start, it will soon accommodate itself to it. Suppose that to illustrate this point we take a round ring 20¼ inches diameter, cut it, snap it into its groove in the piston, and then put the piston into the cylinder. We now find that we can slip a steel ribbon between the ring and the cylinder, say an eighth of their circumference on either side of the joint of the ring. When steam is admitted to this piston, some of it leaks past the ring, and some of it flows under it. It is only reasonable to suppose that as there is no outlet to the groove there will be a greater pressure on the inside than on the outside of the ring; hence it springs out to the cylinder and stops the leak, and after a while it gets worn to fit, and stays out without steam pressure. Of course this way of fitting packing rings to the cylinder is not recommended.

It has been, and may be yet, the practice on some railroads to turn their snap rings the size of the cylinders, then to saw a diagonal joint, and force them over the flanges of the piston into their grooves in the usual manner. The rings are bent enough by spreading them till they will go over the flange, to give them considerable spring, when closed again in the cylinder. I do not believe that this method of using snap rings is to be commended, unless a stiff steel wire spring is put in the groove under them, which prolongs the life of a soft ring having but little elasticity of its own.

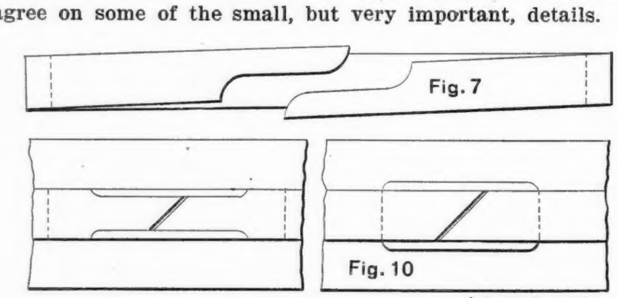
So far, only the diametrical shapes and proportions of snap rings have been briefly mentioned. We now consider their axial dimensions, or width. It is plain that a ring must be wide enough to allow some travel over the counterbore, without danger of springing out into it, if there is a slight change in the length of the rods, or variation in the position of the main shaft, or other like causes. The width required to prevent leakage will in most cases be exceeded by these practical limits. To make a piston steam-tight, it ought not to require a wider ring for a 40-inch cylinder than one 5 inches in diameter, provided the surfaces of the ring and the cylinder and other conditions are the same in each case. In practice, I believe that rings for cylinders between 30 and 15 inches in diameter, are usually made from ¾ to 1 inch wide. There is no single dimension of a detail of an engine where authorities are likely to be further apart, than on the width of packing rings. Unwin gives

$$w = d\,.014 + .08$$

Whitham's formula is

$$w = d\,.15.$$

In both formulas d is the diameter of the cylinder, and w the width of the ring. Unwin makes a 20-inch ring ⅜ inch wide, Whitham, 3 inches. If cylinder wear and lubrication are proportional to the width of packing rings, then ten of Unwin's equals one of Whitham's. It is to be hoped that authors of works on the steam engine will get together and agree on some of the small, but very important, details.



Ring with Side Twist and Ring with Joint Covers.

The ring shown in Fig. 7 is copied from Unwin, but may be found in other like works. While Unwin shows the illustration, he treats it with "a loud silence," when it comes to description. The object in giving the ring a side twist is no doubt to prevent its hammering in the groove, a condition "devoutly to be wished;" but we must remember that a packing ring to be a success in keeping the live and exhaust steam on opposite sides of the piston, must have one edge in contact with the piston, and its circumference with that of the cylinder. If a ring lies in its groove on the "bias" it is easy to see that steam can get into the groove on one side of the ring, and out at the other. Besides, a ring must be active in its groove, or it will soon get stuck fast with burned oil and then it is useless.

In horizontal engines, there can be no leak at the joint of the ring, if it is doweled to the piston near the bottom of the cylinder, for then the flange covers the joint perfectly, as shown in Fig. 8. In two-ring pistons the joints should be

staggered, one on each side of a vertical center line through the piston. So far as leakage is concerned, there is no necessity of the piston being packed except where it does not touch the cylinder. I remember, when we were short on rings, sending an engine out with only a part of one ring, in the left-hand piston. The piece was long enough to pack the exposed part of the piston, and was kept in that position, by a dowel pin at each end. The engine went out, and the engineer did not know that anything unusual had happened to his engine until several months later, when his engine was in for other repairs, and the left-hand piston was examined. When the cylinder head was taken off, the brake was set and steam admitted to the back end of the cylinder. The boys said the piston was "bottle-tight," but that the cylinder was marked along the travel of the ends of the broken ring. Of course a new set of packing was put in.

This incident was the basis of a great deal of speculation aiming at minimum and uniform cylinder wear. I will not narrate the many schemes that were suggested, but show the result in Fig. 9, which does not appear to admit of further modifications, till after-use shall develop such as are necessary.

The chief objection to using steel pistons is that cast steel and cast iron do not always work well together. For instance a steel shaft will run on a cast-iron box as well as on almost anything else, for a variety of purposes; but I do not think it would be good practice to run a cast-iron shaft on a steel box under any conditions; nor a steel piston on a cast-iron cylinder. The advantages of steel pistons do not need to be enumerated further than to say that the lighter the piston the less the cylinder wear, other things, of course, being equal. Hence our design is for a steel head, but so constructed that nothing but cast-iron surfaces shall touch the cylinder.

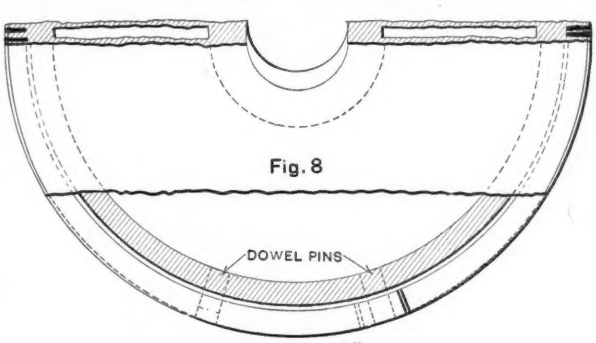


Fig. 8. Ring Doweled to Piston so that Joint comes at Bottom.

Fig. 9 shows a skeleton bull ring, well ribbed, cut in sections, and forced into a groove in the steel piston. The outside of this ring is beveled off to correspond with packing rings whose cross sections are, say, a 30- and 60-degree parallelogram. The packing rings are made in two sections; the top one is 240 degrees long, and the bottom 120. The bottom sections are not made from the same ring as the top, but are made deeper and wider, so as not only to fill the groove clear to the bottom, but also wide enough to be forced into it. To all intents and purposes, they are a part of the bull ring. The top sections, with the exception of the shape of their cross section, are proportioned about the same as snap rings. A flat steel spring, crimped at the top, to fit into a hole in the piston, has a hook at each end, and the action of the spring is to lift and also to expand the top section, while the weight of the piston keeps the bottom section set out to the cylinder. The flanges of the piston are cut away on the bottom to allow for a reasonable amount of wear of bull ring before the flanges can touch the cylinder.

Of course, steam will get under these rings, just the same as though they had a square cross section, but it will not set them out to the cylinder with the same force; for, assuming the joint or contact between packing and bull ring to be steam-tight, the packing ring is steam-balanced in radial directions. Some pressure is necessary between the ring and cylinder, to keep the ring from leaking, but I think it should be constant for all steam pressures, and not vary with that pressure. There can be no doubt cylinders would wear parallel if the pressure was constant; as it is, the wear is most where the pressure is greatest.

Mr. Ramsbottom, an English engineer and inventor of what is called to-day a "snap ring," found them to be tight against 100 pounds steam pressure, with a radial pressure of but 3½ pounds per square inch. With present high pressures, say we use a five-pound tension for rings, then if they are steam-balanced, we shall have but about five per cent. of the ring-friction and ring-wear that we have now. While the direct saving in power would be small, it would simplify the problem of lubrication very materially, and very appreciably lengthen the interval between cylinder borings and bushings. Renewals of packing ring and piston adjustments would also be less

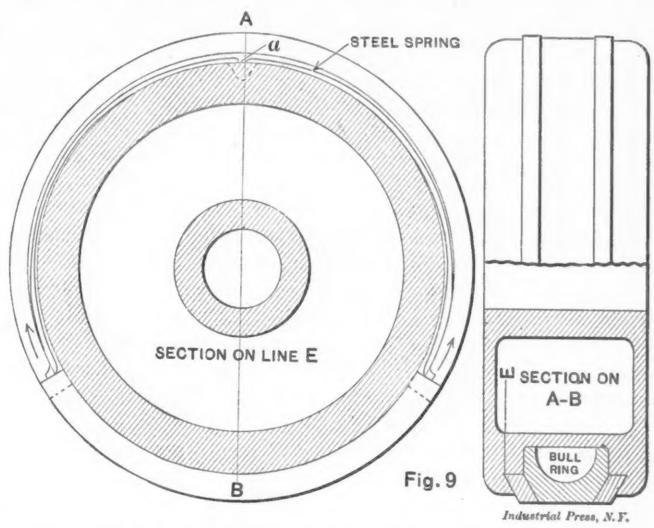


Fig. 9. Piston having Skeleton Bull Ring and Beveled Packing Rings.

frequent. I shall have to plead guilty to discussing this same topic in my last letter under this heading, and as an apology will say that the subject does not seem to be exhausted.

Fig. 10 shows two of the most popular joint covers for packing rings. In one, the edges of the ring are reduced to receive a cover-piece; in the other, the groove is milled out to let it in. In both, the cover-piece is held out by a spring, usually a flat one riveted to it. In the former the ring may revolve in the groove, while in the latter it must be doweled to the piston.

* * *

Probably there is no more severe test of a man's qualities than to subject him to entirely changed conditions from what his life training has used him to. This applies as forcefully in the machine shop as elsewhere. Machinists are constantly being called on to change their methods, to adapt themselves to new machines and to adapt old machines to new work, etc. The quickness of the American mechanic to do these things is almost proverbial and it is one of the secrets of our mechanical success. The comparatively recent advent of the high-speed tool steels has worked practically a revolution in many American shops in the matter of output, and it has also made necessary a complete re-designing of the line of machine tools built by most makers. Our English contemporaries complain of the stubbornness of their machinists in adapting themselves to the changed conditions since the advent of the Taylor-White process. One of them seriously states an ignorant laborer brought in to attend a heavy lathe will soon secure double, treble or even quadruple the output of the experienced man who cannot or will not grasp the significance of the new order of things. The laborer is not afraid of cutting speeds of 60 or even of 100 feet per minute because he knows no different. While there may be a grain of truth in these caustic remarks, as far as it applies to English shops, we are pleased to note that in American shops there is little trouble in getting lathes and other machine tools worked to their full capacity when using high-speed steels, especially where the manufacturer is willing to pay for the additional work. Perhaps "there's the rub" on the other side for it has become a pretty well-defined English policy to allow a man to earn only about so much regardless of what his output is.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

One of the striking novelties proposed for the St. Louis Exposition, is an imitation $1,000,000,000 gold coin, that is, one in size that if made of solid gold, would be worth the sum stated. Taking a $20 gold coin as the standard of measurement, the imitation $1,000,000,000 coin will be 40 feet in diameter and 30 inches thick.

The *Mechanical Engineer* states that what is probably the largest steam boiler ever built, is that supplied by Normand & Co. for a torpedo boat built for the French Government. The boiler is of the water-tube type and supplied steam for 3,550 indicated horse power. Allowing a steam consumption of only 12½ pounds per I. H. P., the boiler had to evaporate 746 pounds of water per minute. "That's bilin' water purty fast."

In a paper read by P. M. Lincoln before the American Institute of Electrical Engineers, at a recent meeting, reference was made to the extraordinary sensitiveness of the ordinary telephone receiver which makes it one of the best detectors of electrical disturbances known, if not the best. An authority is quoted who says that the energy used in an ordinary 16-candle power incandescent lamp is sufficient to produce an audible sound in 30,000,000,000 receivers!

In the April *World's Work* the writer of an article on conveniences in the modern model American residence, mentions the growing use of acetylene gas apparatus for lighting isolated homes, far removed from municipal gas plants, and in connection says that the spent carbide which has always been thrown away, has recently been discovered to be a valuable fuel. Mixed with coal clinkers it burns with intense heat in an ordinary house furnace. So it appears that another "waste" product can be profitably utilized.

An oil fire is one that is practically impossible to extinguish when it is extended over an area of much size. Water is worse than useless for extinguishing an oil fire as it simply spreads it and makes it worse. At the recent (April 15) $1,000,000 fire on the famous Spindle Top in the Beaumont oil region of Texas, it was again demonstrated that steam is an invaluable agent for extinguishing oil fires. The steam from a stationary boiler was turned on a burning ditch of oil in which the flames were several feet high with the result that they were completely extinguished and prevented from spreading into a valuable section of the field that otherwise would have been burned over.

The United States commercial agent at Eibenstock, Germany (Ernest L. Harris), calls attention in a recent consular report to a German device for automatically drawing off condensation from steam engine cylinders without wasting steam. The device appears to consist essentially of a pair of poppet valves mounted in a suitable case which is inserted in the middle of a pipe communicating with both ends of the cylinder. The valves are alternately opened and closed by a tappet worked by the valve motion, and the water drains out during the exhaust strokes. The discharge pipe of the apparatus is connected to the condenser in the case of condensing engines. It is manufactured by Schneider & Helmecke, Magdeburg, Germany, and its success in that country is said to have been marked.

An apparently impossible result may sometimes be attained by an inversion of the ordinary process. *Stahl und Eisen* in a recent issue describes a case in point. The refractory lining of a blast furnace of the Metz works at Eschsurl Alzette, Lorraine, was nearly destroyed after eight years' use. When this condition was reached in February, 1899, the market price of iron was so high and the demand so great, that serious loss would have been entailed on the whole plant by shutting down to re-line the furnace. A new refractory lining of firebrick was built outside the red brick exterior, brackets having been applied to support the new wall. The brackets were applied in 1899, but the wall was not built until 1900 when gas was escaping from cracks in the old wall. Although the interior volume was increased by nearly 5,100 cubic feet from the original size it is claimed that the operation is fairly satisfactory.

John Brisben Walker made an address recently before the New York Rapid Transit Commission in which he advocated a complete revolution in present methods of city transportation, employing automobiles in place of street, elevated and sub-service cars, or rather in conjunction with them. Mr. Walker argued that but comparatively few passengers could be carried in each vehicle (all of which would have seats) so that it became to all intents and purposes a through train making the trip in quick time and with most passengers, a minimum of trouble and annoyance. Not being confined to streets with rails the automobile system would be free to extend to any and every street, and he believes that the system can most successfully compete in the matter of cost and convenience with the present ones. Whether this idea will ever be realized to the extent advocated, or not, time will only reveal, but the indications are that the automobile will soon displace the horse-drawn cab, because of its greater cheapness and speed, which make it a more reliable and agreeable means of getting about, to those who can afford to travel more expensively than by street cars.

Consul Frank H. Mason of Berlin reports that that city has one of the most satisfactory electric traction systems to be found in any city in the world. The elevated and underground electric railway, constructed by Siemens & Halske, has been in operation for a year and has proved a remarkable success. It has very low rates for fares, and yet the profits have exceeded the estimated profits for the first year of operation by 80 per cent. It carries passengers a distance of three miles in 10 minutes for from 2½ to 3¾ cents, according to the class of car. It is probable that this system will be very much extended to other points of the city and experiments are under way looking to a transformation of the steam railroad system between Berlin and distant points, establishing more intimate interurban communication. It is proposed to substitute for the three or four long express trains which run daily between these cities hourly three-car trains capable of carrying about 100 passengers and baggage, at a speed of 75 miles an hour. Prizes have been offered by the National Society of Mechanical Engineers for the best designed locomotive and cars for this service and tests that are to be held in the near future will be awaited with considerable interest.

The Transandine Railway, which is now nearing completion, is a most important South American engineering enterprise, not only because of the enormous physical difficulties overcome in its construction, but vastly more because of the stimulating effect it will have on the commercial relations of the two countries thus brought into intimate contact, notwithstanding the Andean barrier between them. The new railway, which is nearly 150 miles long, forms the connecting link between the trunk lines of Argentine Republic and the state railways of Chile and gives through railway communication between the eastern seaport, Buenos Ayres, and the western seaport, Valparaiso. It completes the first railway line to cross the continent of South America. The terminals of the connecting link are Mendoza (2,800 feet) and Los Andes (3,000 feet), and the highest point in the line is 10,450 feet above sea level. At the summit the line passes through a tunnel 12,800 feet long. This, however, is not the highest point reached by commercial railways, the Ferro Carril Central del Peru, in Peru, having that distinction. Where this line crosses the Andes it is 15,665 feet above sea level—the highest point reached by any railroad in the world.

BEAUMONT OIL WELLS.

The oil wells in the Beaumont region are not drilled with a jump drill as they are almost universally in other regions where the oil strata is only reached by penetrating rock. In the Texas fields the oil strata lies beneath earth and quicksand, and the ordinary method of drilling cannot be employed. The first wells in this locality were abandoned at shallow depths because the quicksands filled the bore faster than it could be bailed out. The prospector, A. F. Lucas, who discovered oil at Beaumont was forced to abandon his first well from this cause, but he later tried another method by which the first famous gusher was "brought in." In this method an eight or ten-inch casing pipe is sunk into the ground by washing the earth away from the bottom and forcing it up through the pipe. The earth is loosened by a flat drill attached to the bottom of an inner four-inch pipe by straps so that the opening is clear. Through the interior four-inch pipe, water is forced downward and at the same time the drill is revolved. The water and earth rise in the outer pipe, which is forced downward at intervals as the hole descends. The four-inch pipe is turned by suitable gearing attached to the upper end and connection is made to a steam pump by means of a cap and stuffing-box which permit the pipe to turn freely, yet confine the water. The first Lucas well struck oil January 10, 1901, at a depth of 1,120 feet. Prof. O'Neill, in *Sunset*, says that the flow of oil, water and gas threw out 700 feet of four-inch pipe weighing about six tons, carrying away part of the derrick, and the spray and stones went 300 feet upward in the air. The flow was estimated at 75,000 barrels a day, and in a short time it covered an area of nearly 100 acres, being confined by levees. No wonder people went crazy with the speculative fever. Everybody began to drill wells and the derricks on Spindle Top were soon so close that they actually touched one another in some places. So much oil was thrown on the market that the price went down to two and three cents and even to one cent a barrel at the wells.

THE UNION ENGINEERING BUILDING.

In the early part of May the announcement was made that Andrew Carnegie had offered to give $1,000,000 to the four great engineering societies of America and the Engineers' Club of New York City, for the erection of a union building in New York to be the common home of these five organizations. The plan of having a great engineering headquarters in this city, where the engineering interests of both the city and the country at large should be centered, has been long talked about as a possibility, though hardly as a probability, because of the enormous expense of such an undertaking. With the gift of Andrew Carnegie, however, the possibility changes to almost a certainty, depending only upon the favorable action of the various societies involved.

It is worthy of note that this generous action by Mr. Carnegie was entirely spontaneous, coming as the direct result of a meeting of the American Institute of Electrical Engineers which he attended and at which addresses were made urging a unification of the branches of the engineering profession in so far as it should be possible. To carry out the project, pending the acceptance of the gift, options have been secured on property immediately adjoining the site of the new New York public library building, which if finally used, would bring the two libraries in adjoining buildings—an arrangement much to be desired. Mr. Carnegie proposed that the organizations pay for the land for the building, and he estimated that with what they were now subscribing for rent they would be able to care for a building such as he would be glad to provide, and so the sum comprising his gift is to be devoted solely to constructing the building itself. Committees have been appointed by the societies interested, who have plans under advisement for carrying through the project in all its details. The only hitch in the proceedings that is likely to occur may come in the action to be taken by the American Society of Civil Engineers, which is the strongest of the engineering societies and owns a handsome new building of its own, entirely adequate to its needs for many years to come. Anticipating a possible disinclination of the members of this society to abandon its present home in favor of the union headquarters, the *Engineering News* has sent out letters to forty leading men of the profession, asking an expression of opinion upon the advisability of the move. The replies were very gratifying as showing a strong sentiment in favor of the Carnegie plan, and it seems fair to presume that the opinions expressed in these letters voice with a fair degree of accuracy the views of a majority of the members of the society.

A. S. M. E. COMMITTEE REPORT ON THE METRIC SYSTEM.

The report of the committee appointed at the last regular meeting of the American Society of Mechanical Engineers to investigate the subject of the metric system has been issued and distributed to the members. The appointment of this committee was the result of Mr. Halsey's paper upon the metric system last winter, which led to a more extended discussion than any other paper ever presented before the society. A committee had previously been appointed to report upon the metric system, but as it was composed entirely of men with preconceived ideas against the system and their report was accordingly unfavorable to the system, the second committee was named, having two members, Mr. Christie and Mr. Miller, for the metric system, and two members, Mr. Kent and Mr. Bond, against the system, with the view of obtaining a fair and impartial review of the question.

As a matter of course the four members of the committee could not get together on common ground and present a common report, as there was not a majority either for or against. The bulk of the report is therefore made up, first, of the "pro-metric" argument by the two metric members, and the "anti-metric" reply by the anti-metric members, and second by an anti-metric argument and pro-metric reply. After these are several pages of notes, comments, extracts from the press, and various data bearing upon the subject in general. This pamphlet has 72 pages, and Mr. Halsey's paper and discussion, which accompany the report of the committee, make up a pamphlet of 231 pages. These two present a mass of matter upon the metric system, pro and con, such as it is safe to say was never before gathered together, and may never be again. From the various pages one can find arguments to prove anything he wants to about the question, exactly adapted to his own ideas and notion of things. The papers do not prove anything one way or the other; they probably will not convince anybody one way or the other; but nevertheless are very good documents to have on file. The beginning of the report of the committee of four is composed of a few paragraphs that all the members subscribe to and represent probably the only main points upon which they are generally agreed, and possibly upon which any similar committee could agree. They are as follows:

1. Legislation designed to compel the exclusive use of the metric system is not desirable.

2. We believe that such legislation could not be enforced in any event so far as transactions between private individuals are concerned.

3. The general government has the power to specify the system to be used in its own work and business and can require that work done for it by contractors shall conform to any specified measurements or weights.

4. The government cannot compel anyone to bid upon its specifications.

5. Recognizing the well settled fact that the consumer does and must pay all necessary costs of production, we believe that if the government specifies such dimensions as will materially increase costs of production, the government and not the bidder will have to pay such increased costs, it being self-evident that a bidder, not compelled to bid, will not bid except at a price which will afford him a profit.

6. The bill now before Congress is intended to make the use of the metric system compulsory in the several departments of the government, but it cannot make it compulsory in private transactions.

7. We believe there is no force in that class of arguments which consists in taking integral dimensions in one system, translating them into equivalent and therefore fractional dimensions in the other system and then making comparisons. Such arguments can be made as strong for the one system as for the other.

GAS PIPE LINE.

L'Echo des Mines et de la Metallurgie, March 2, 1903, p. 247.

It is proposed to erect gas houses at the mines and produce gas that is to be taken to Paris under a high pressure through pipe lines to be supplied for heating, lighting, power and electric generation purposes. It is thought that this can be done and the delivery made for .05 franc per cubic meter, which is equivalent to about 28½ cents per 1,000 cubic feet. In regard to the liquefaction of the hydrocarbons by pressure or cold either singly or combined, it is argued that the temperature of distillation has a considerable influence upon the fixation of the same. Gas made at a low temperature precipitates more benzol than gas produced at a high one. Oil gas is richer in hydrocarbon than the richest coal gas, and yet this is subjected to exceedingly high pressures for transportation. Means are suggested for draining the pipes, and the ammoniacal liquor so obtained is to be used directly for fertilizing purposes instead of the salts, as at present.—G. L. F.

LOCOMOTIVE MAGNETIC TRACTION INCREASER.

Railway Age, April 10, 1903, p. 705.

The use of magnetism to increase the adhesion of locomotives has been frequently suggested, and experiments made on a small scale seem to indicate that a great increase of adhesive power could be obtained in this manner. The article under review was called forth by a magnetic traction increaser that is being exploited in Chicago and for which apparently most extravagant claims are set forth by the company, who say that an increase of adhesive power from 200 to 300 per cent. is possible. It is shown, however, that according to well-established laws of magnetism, the magnetic density of the magnets could not practically be made such as to increase the effective load on the drivers on a 100-pound rail more than 1,500 pounds, allowing an area of contact of ¾ square inch. This is, of course, an addition of only about 10 per cent. of the average weight on the drivers of modern locomotives. While the small-sized models do undoubtedly show a wonderful increase in the adhesive power, the increase is not in proportion with a full-sized locomotive. In fact, the figures given above are liberal and it is quite doubtful if they could be reached in practical application.

THE BROADENING EFFECT OF INTERCOURSE.

Youth's Companion, May 21, 1903.

For many hundred years manufacturers and craftsmen of various kinds guarded the secrets of their trades as if success depended upon keeping competitors ignorant of their methods. Monopoly of trade was sought through monopoly of knowledge. The day of the trade secret has passed, although there are some survivals where manufacturers are not content with the short monopoly that the patent system gives them. In its place has dawned the day of trade conferences, in which men discuss processes of manufacture and methods of sale. Men engaged in distinctively intellectual occupations have long recognized the necessity of getting together to compare notes and to talk over the things in which they had a common interest. The conferences of ministers and medical associations are good examples of the practice. Although there have been boards of trade and chambers of commerce for years, the trade conference in its present form is a recent product. It is the result of the broader education of the world which has made men dissatisfied until they had learned all there is to know about the thing in which they are interested, whether it be the manufacture of locomotives, the raising of beets, or the origin of Greek roots.

FINISHED MACHINE WORK.

Mechanical World. (Manchester) March 13, 1903. p. 121.

After considerations of price and utility, buyers of machinery are regardful of appearance in the articles they purchase. Other things being equal, the machine with most bright work has decidedly the better chance of being sold, and not infrequently bright parts and a high finish will effect a sale in spite of a high price. This fondness for polished work is, in the opinion of some engineers, a mere fad—a waste of money on the part of the buyer; and they maintain that all the polished work in the world will not increase the efficiency of a machine. Yet in spite of this we venture to say that the man who chooses the bright machine generally makes the better bargain, taking full account of the increased price he has paid. Probably he buys the bright tool simply to please his artistic sense, but there are advantages in bright work beyond a mere pleasing appearance. In the first place, the manufacturer is compelled to select good materials for those parts which must take a high polish. Inferior metal would not pay, because of the difficulty of imparting a high finish to it. Another advantage of bright work is that it often shows flaws in the material which would have remained concealed in a black job. The buyer of a bright job has therefore some guarantee that those parts highly finished are of good material. There is yet another consideration which is all in favor of the bright finish. The owner can see at a glance whether the machine is properly attended to, and whether it receives rough usage at any time. In overhauling the machine the attendant is bound to use the bright parts with care. He dare not strike any of the bright parts with a naked hammer, nor dare he use bright nuts with violence, as the rough treatment would be detected. Hence for his own sake he will endeavor to keep all parts easy, so that when there is overhauling to be done there will be no necessity for rough usage in getting the parts asunder.

REGARDING THE FIRST STEEL MADE IN AMERICA.

Iron and Machinery World, April 25, 1903, p. 32.

W. M. Atherton, of Chicago, Ill., while at Afton, N. Y., a few weeks ago, discovered an old document of considerable historic interest, being a contract made by his grandfather, Cornelius Atherton in 1772 to instruct John and Ezra Reed in the art of making steel. The subject of the contract was of great importance to the colonists at the time it was written, as they were entirely dependent upon the mother country and Germany for all the steel they used, and even the German steel could reach them only through a British port and British bottoms. How Cornelius Atherton became possessed of the secret of making steel is not known; that he was the first manufacturer in the United States is a fact well authenticated. The Reeds were merchants and carried on the Dover Iron Works, adjoining the town of Amenia. The old steel works were built by Cornelius Atherton under this contract.

Cornelius Atherton was born in Cambridge, Mass., 1736, and came to Amenia in 1763, where he soon became the manager of the Dover Iron Works. In 1769 he returned to Boston, and in partnership with John and Samuel Adams and John Hancock commenced the manufacture of firearms and cutlery. Here he made his first successful experiment in steel. At the end of six months the works were burned by an incendiary, supposed to be the British soldiers then quartered in Boston. In 1770 he returned to Amenia and built the steel works in the latter part of 1772, and in 1773 went to Plymouth, Pa. He settled on the land upon which the Shupp's mill was afterward built. Here he made steel in small quantities, and manufactured blacksmiths' anvils and made rifles for the hunters. During his residence there he began to use anthracite coal in his shop. In 1773 he went to Florida, Orange Co., N. Y., where he remained until 1783, when he returned to Taylorville, Pa. During his residence there he constructed the old Wright forge, also the forge of E. & B. Slocum at Slocum Hollo, now called Scranton, Pa. At this place he made steel in small quantities. He died at South Bainbridge, N. Y. (now Afton), in 1809.

PETROLEUM LUBRICATING OILS.

Abstract from Paper read by W. F. Parrish, Jr., before the New England Railway Club, April 30, 1903.

The author states that the birthday of the petroleum business of the world was August 28, 1859, when Col. E. L. Drake struck a 25-barrel oil well on Oil Creek near Titusville, Pa., at a depth of 169½ feet, boring the hole after methods suggested by Bissell. There are three general methods of distilling petroleum which are followed according to whether the desired product is burning oil or lubricating oil:

1. Destructive distillation, or "cracking." The crude oil is

placed in a still with a large dome and heated to a certain temperature, when the fires are slacked and the distilling allowed to proceed slowly. The distillate passing off condenses on the cooler dome, and finally falling back into the hotter liquid below is further broken up. This is termed "cracking," and is the general method used in manufacturing burning oils. A large amount of product can be obtained in this way. The residuum is used for the manufacture of lubricating oils, etc. This residuum, if simply distilled and purified by chemical treatment after the removal of the paraffine, is what is known as "paraffine oil" in this country.

2. Distillation by the introduction of superheated steam. This is done to prevent the overheating of the oil.

3. Distillation in a vacuum. In this process a partial vacuum in the still is maintained by a pump, and a higher comparative temperature may be used without danger of destroying any of the parts of the crude.

The last two processes are the ones used by the manufacturer who regards the lubricating oil as of first importance.

The author then goes on to show the prime importance of purchasing lubricating oils with some knowledge of their manufacture. He states that a change of the set of oils used in textile mills very often results in the saving of from 5 to 15 per cent. of the power expended. Seven per cent. reduction in power in the average textile mill will equal the price paid for the better oil.

Properly made engine oil can be used over and over again indefinitely if filtered and settled. Automatic oiling systems are advocated for all power plants, using pumps and gravity feed. A lighter oil can be used and fed on the bearings in a stream, which is the most effective method of lubrication known.

INDEPENDENT AIR-PUMPS AND CONDENSERS.

Electrical Review (London), May 8, 1903. p. 803.

In his usual clear and forceful manner, Mr. W. H. Booth points out a practical disadvantage of the independent condensing set in stationary practice that may be unsuspected by many power plant engineers. Of course when an independent air-pump is employed, its speed may be regulated exactly to what is necessary. If the vacuum falls the pump may be speeded up, and if it is too high the speed of the air-pump may be reduced. But this flexibility of action is the chief disadvantage of the independently-driven condensing set. Young engineers are exceedingly perfunctory in their behavior towards a condensing plant. They look upon the air-pump as a pump for air, and take good care to supply plenty of air for it to remove. The air-pump is certainly intended to remove air, but it is only intended to remove a certain irreducible minimum and with surface condensation this minimum should, obviously, be very small indeed. As a fact, it is usually very large, and when an engine is shut down and all valves and cocks about it are closed, the vacuum gage on the condenser falls rapidly to zero, whereas it should not fall below 24 inches in the course of an hour. This is a practical possibility. In theory it should never disappear, but it is excellent and exceptional practice which can show a 24-inch "vacuum" after an hour's stoppage. If anything like this can be shown, the air-pump is not being saddled with much unnecessary work, and should easily maintain a working vacuum of 26 to 28 inches. If, however, the vacuum does not hold up well in the stopped engine, it may be bad to run the air-pump fast enough to maintain 24 inches. Now this is what many engineers persist in doing. They have a vacuum which will not hold up well when the engine and air-pump are stopped, but they keep it up to 22 or 26 inches by driving the air-pump at an excessive speed, with great waste of power. This is where the independent air-pump appears at fault. By its means a poor vacuum is made as good as possible by furious running of the pump instead of by searching for and stopping leaks in injection and exhaust pipes, at glands and cocks, and many other weak spots in the chain. When the pump is driven off the engine, it can never be run beyond its designed speed, the vacuum drops in response to an air leakage, and cannot be improved except by stopping the air leak.

POWER FROM BLAST FURNACE GAS.

Electrical Review. April 4, 1903. p. 463.

More and more attention is being given to production of power from combustible gas, especially in motors of the internal combustion type; and to ways and means for utilizing the lean waste gases from metallurgical plants. The development of the gas engine has reached a point where it is perfectly safe for a large manufacturing establishment to use gas engines for motive power. To manufacture gas for power cheaply, gas companies have been organized in different cities to supply producer gas for fuel and power. The possibility of using lean gases economically when they are manufactured especially for the purpose, only serves to draw more earnest attention to the enormous waste of combustible gases that takes place daily in our blast furnaces. For the production of each ton of pig iron it is estimated that gas capable of generating 13,587,000 B. T. U. and weighing nearly 10,590 pounds, is produced which is now for the far greater part entirely wasted. The development of blast furnace engines has reached its highest point in Germany, which country leads all others in this respect. The majority of the gas engines in operation in Germany are over 500 H. P. and a number are as large as 1,000 and 1,200 H. P. One pound of blast furnace gas generates 1,283 B. T. U. and from 20 to 30 per cent. of this energy can be utilized. One horse power is equivalent to 2,545 B. T. U. and on a basis of 25 per cent. efficiency something less than 8 pounds of blast furnace gas will generate one horse power. The gas from a blast furnace producing only one ton of pig iron an hour, allowing a waste of 25 per cent., should, if properly utilized, produce nearly 1,100 horse power hours. This vast amount of waste power would be sufficient to operate a large power station.

The importance of this is further emphasized when we consider the industry of pig iron production in the United States. The average rate of production of pig iron amounts to nearly 1,500,000 tons per month. The gas generated by the blast furnaces for making this amount of pig iron would be sufficient to run several manufacturing plants, and incidentally produce more power for electrical purposes than Niagara. The power generated by the gas could furthermore be utilized for running the blast furnace plants, and still leave a surplus more than three times as great for other purposes. The operation of pumps and blowing engines by steam generated by coal as fuel could be replaced by electrical generators driven by gas engines.

METALLIC TUBING AND TUBE FURNITURE IN GERMANY.

Consular Reports, April 30, 1903.

The manufacture of tubes and pipes from iron, steel, copper, and other metals and alloys, although of comparatively recent date, is one of the most extensive and highly developed industries of its class in Germany. There were in operation at the close of 1900 seventy-seven manufactories of metallic tubing, some of which—as, for example, Predboeuf et Cie., the Mannesröhrenwerke, and the Röhrenindustrie, all at Düsseldorf—are large establishments with ample resources and equipped with every facility for cheap production on a large scale.

The Mannesmann process for rolling seamless tubes and the Ehrhardt system by which seamless pipes are drawn by forcing a mandrel under hydraulic pressure through a block of metal, are both German inventions which have been developed and worked with notable success in this country; while Larson's Swedish process for making steel tubes, the Murphy process, and the Robertson and Elmore patents for making copper and brass tubes are all employed here under the most advantageous circumstances.

Among the various uses to which iron, steel, and brass tubing are applied in Germany, one of the most modern and important is the manufacture of furniture—especially bedsteads, cot frames, and tables for household, hospital, and military purposes. Tubular metallic bedsteads are not only cheaper, lighter, and more easily flexible than those made of wood, but they offer no harbor for vermin and lend themselves readily and without injury to disinfection and all the processes of sanitation. For these reasons and because they are cheap, light, and serviceable, the manufacture of tubular bedsteads

and other articles of furniture, which began in England and was adopted in Germany hardly a dozen years ago, now employs capital estimated at 15,000,000 marks ($3,570,000) and from 50,000 to 60,000 operatives. As the industry has developed, there has been a steady progress in the effectiveness of the machinery employed for shaping, cutting, and jointing the parts; soldered joints have given place to screw connections, detachable when desired.

Bedsteads are made either wholly of iron and steel tubing, of the same tipped and decorated with brass and nickeled mountings, or wholly of brass tubing, the latter class being, of course, the most decorative and expensive and adapted to luxurious households, hotels, and private sanitaria. When intended for hospitals, iron bedsteads are covered with a waterproof varnish, which protects them from oxidation or injury in cleaning or disinfection.

THE LJUNGSTROM CONDENSER.

Abstract from Paper read by William Cross before the British Institution of Naval Architects.

The paper describes a new form of steam engine condenser invented by F. Ljungstrom, a Swedish engineer, which is remarkable for the great efficiency of the condensing surface as compared with the ordinary surface condenser commonly used in marine service. The area of condensing surface usually allowed per indicated horse power for triple expansion engines in the merchant marine, is about 1.3 square feet. For the somewhat more economical engines of the British navy, and on account of the restricted space, the condensing surface is cut down to about 1.1 square feet per indicated horse power for the heavy powered vessels like battleships and cruisers, and to 0.75 square feet per indicated horse power in the case of torpedo boats. Small vessels fitted with condensers consisting of D-shaped copper pipes attached to the outside of the hull, have the surface still further reduced to about 0.50 square foot per indicated horse power. The Ljungstrom condenser requires only 0.27 square feet of condensing surface per indicated horse power for equal engine efficiency.

Briefly, the Ljungstrom condenser consists of a number of thin diagonally corrugated chambers or elements of brass fixed together in packets, so arranged that the corrugations mutually support one another. These packets are fixed in a rectangular casing in such a manner that the cooling water flows horizontally through the chambers, and the steam flows vertically outside the chambers, it being understood that the space through which both steam and water have to pass is limited to the depth of the corrugations. The result is that a very large number of fine streams of steam and water are compelled to travel a sinuous course in close proximity to each other, being only separated by the thin walls of the corrugated chambers. The upper part of the rectangular casing is full of steam at a pressure due to the exhaust, while the under side is open to the air pump, the two being separated by the packets of corrugated chambers. The steam therefore is constrained to pass along the corrugations in intimate contact with the cooling water, and with sufficient velocity to sweep with it all condensed water. The action is thus very different to that in a condenser of the ordinary type where the steam is admitted into a large chamber full of cooling tubes, and allowed to wander about until finally condensed, when it drops to the bottom and is drawn-off by the air pump.

In large condensers the evil of the steam endeavoring to take a short cut to the suction pipe is, to a certain extent, recognized, and diaphragm plates are fitted so as to compel the steam to traverse more completely over the tubes, but even then it is certain that the circulation of steam is very defective.

SLIPPING OF LOCOMOTIVES AT HIGH SPEED.

Mechanical Engineer, May 9, 1903. p. 624.

The writer, Mr. C. E. Wolff, refers to the obvious and well-known fact that when the horizontal inertia forces in a locomotive are balanced, a vertical disturbing element is introduced which causes a variation in pressure of the driving wheels on the rails. Since these forces vary as the square of the velocity, there is clearly a limit of speed beyond which the drivers will lift clear of the rails every revolution. Consequently slipping must take place at certain points when the speed is such as to cause the adhesion of the drivers to fall below the tractive force of the locomotive. Based on this theory Mr. E. L. Hill in 1892 predicted that it would be impossible to run one of the Midland single-driver locomotives faster than 80 miles an hour, but unfortunately for his calculations the engine subsequently drew a train at 87 miles an hour. With the view of discovering the reason of the apparent contradiction of theory and fact the writer made an investigation of the subject with results that are not without interest.

Plotting the tractive and adhesion curves he found that the curve for adhesion fell below the tractive effort curve, it is true, at the higher speeds, but only for a period of time of about 1-18 second for the locomotive investigated by the author. Hence before the driving wheels have had time to acquire any great velocity the adhesion is once more greater than the tractive force and no slipping takes place until the crank arrives at the same point in the next revolution.

In order to test this matter the results of Galton and Westinghouse's experiments on the coefficient of friction at different velocities of slipping were made use of. These results showed that the value of the coefficient of adhesion is very accurately given by the expression $\frac{4}{V + 20}$ where V is the velocity of slipping in feet per second. The moment of inertia of the driving wheels and axle was known, having been calculated for some previous tests in connection with the same engine. From these data the accelerations and velocities of slip were calculated for successive intervals of 1-500th of a second, the coefficient of adhesion for any interval being obtained from the velocity of slipping at its commencement. No appreciable error is introduced by this method of calculation, as the intervals of time were so short that the increase of velocity during any one interval was very small indeed. As a matter of fact, the maximum increase of velocity never exceeded 1 foot per second.

The result shows that the total slip to be expected under the conditions of the test at 35 miles per hour is about 86 inches per mile, or ⅜ inch per revolution, while in the test at 65 miles per hour the corresponding figures are 18 inches per mile, or less than 1-10 inch per revolution. It would appear that the adhesion curve may fall very considerably below the curve of tractive force during part of a revolution without continuous slipping taking place. It is also worthy of note that the smaller the diameter of the driving wheels the greater will be the variation in the adhesion. Hence it is possible for the percentage slip to be much greater in the case of a coupled engine with small wheels than in the case of a single engine having large driving wheels without the slip ever becoming continuous. As this slip represents a pure waste of energy, this fact may serve to partially explain the superior economy of engines having large driving wheels.

MANUFACTURE OF COLD ROLLED SHAFTING.

Modern Machinery, May, 1903. p. 148.

Open-hearth steel of a low percentage of carbon, is the material most generally used for making cold rolled shafting, but it must be most carefully made and perfectly homogeneous throughout, otherwise the hard spots will cause the shaft to "cockle" in the planishing process. After being heated to a good yellow heat the ingot is passed through an ordinary pair of reducing rolls until it is rolled to about one-half inch larger than the finish diameter, the allowance, of course, depending on the size of the shaft.

The next pair of rolls that the bar is passed to on its journey (for this is a continuous operation and the ingot commences at one end of the mill and never stops until it is ready to be planished at the other end) is of an entirely different kind than the ordinary rolls, being a pair of horizontal pass rolls with a pair of vertical rolls just behind each gully and of a slightly smaller diameter than the preceding one. As it is necessary to impart a rotary motion to the bar, as it passes

through these rolls for the purpose of leaving no seam on the bar, one of the vertical rolls is slightly skewed relatively to its mate, thus bringing their centers out of line and imparting the rotary motion that is so essential to the high finish given to the bar at the end of its journey. The shaft is passed through these rolls until it is reduced to about 1-64 inch of the finished size and when cold enough to handle is taken to the planishing lathe for the final operation.

This operation is only resorted to, to finish the highest class article that is turned out, as the horizontal and vertical rolls can be adjusted to finish the bar very closely; but to get a bar that is absolutely straight, and of the right size, the planishing lathe must be resorted to. This lathe is especially built for the purpose and has a pair of hardened steel rollers set in a frame on the carriage. These rollers must be made very accurate and polished to the highest degree, otherwise the bar will show each inaccuracy or flaw as the rollers pass over it. The size most generally used is about 4 inches diameter by 2½ inches face, nicely rounded off and one roller set ½ inch ahead of its mate. The bar is placed in the lathe in the condition it came from the mill and the rollers are forced together by a hardened steel gage until the required size is obtained. The feed is thrown in and the rollers begin the journey and put the size and finish on the bar that is almost impossible to obtain with the turning lathe. The travel of the rollers is very rapid as the lathe is run at high speed and the bar is soon finished so far as this part is concerned. After being taken from the lathe, the bar has a beautiful smooth finished surface and will be found as straight as it is possible to make it; and if the condition of the tools used is as it should be, the bar, after passing to the cold saw to be sawed to length, is ready to be made part of any engine or machine that requires accuracy of finish and beauty of material entering into its component parts.

As this high grade product commands a good price on the market and the uses for it are becoming more general each year, no expense or care is spared in the machinery used in its production. Large sums are spent to produce rolls that will do the work in the most efficient manner and great care must be exercised in their adjustment to manufacture a product that will compete with the best lathe work obtainable. Water is used as a polishing medium on horizontal and vertical rolls, and the best result is obtained with a fine spray as a heavy stream cools the bar too quickly. With the proper mixing of the metal in the first process the bar when finished needs no annealing, but as this is not always done, annealing is sometimes required to have the bar soft enough to work properly. Especially so when the proportion of carbon is greater than it should be; but as the art of making open hearth steel has become a science, one might say the product from old established firms is very uniform and gives the best of satisfaction to the user of this modern and splendid product of the rolling mill.

HIGH-SPEED TOOL STEELS.

Abstract from Paper read by William Lodge before a recent meeting of the Cincinnati Machine Tool Manufacturers and Published in the Iron Trade Review.

In using high speed steels on cast iron we are obliged to drop down to a speed of about 45 feet per minute in order to get the best results; and while a good deal of cast iron may be turned at 70 feet per minute, if this feed is given to the workman he becomes confused as soon as he strikes a casting a little bit harder than will admit of this speed. I find in general that the ordinary workman does not reason cause and effect sufficiently well to know that the fault lies in the iron being a little harder, but is rather inclined to fall out with the whole institution as requiring something unreasonable. Forty-five feet per minute on cast iron is double what we have been accustomed to, and all day long the high-speed steel will show about the same tendency to become dull that the ordinary tempered steel formerly showed at 20 feet.

In taking light cuts in cast iron we may readily run up to 100 feet and even more per minute. On the same line of argument, 75 feet for steel in roughing would be more economical than a much higher speed on an entire day's run, because if the extreme high speeds were to be kept up all day, it would require a foreman or superintendent to about every three men, which we all know would not be at all economical. We have found more astonishing results, perhaps, in using this steel for the boring of spindles than in the turning. It will astonish some of our members, I know, when I say that we can bore 50 carbon steel all day long about as follows: Our 24-inch lathe spindle is 44 inches in length. In this we bore a 2⅛-inch hole, and we do this in 58 minutes. In an entire day's run, counting the mounting into the machine and the taking of it out, we average eight spindles on one machine in ten hours. Our 14-inch lathe spindle is 24 inches long, and in this we bore a 1¼-inch hole in 18 minutes. The tail spindle for the 24-inch lathe receives a 1⅛-inch hole its entire length, less two inches, and we can readily bore this hole every nine minutes.

On finishing operations and light cuts and in 30 carbon steel we do run up to 200 feet, and find on this class of work that a high speed and a fine feed are more economical than attempting a lower speed and coarser feed, preparing the work for the grinding machine so as to leave less work on the grinder. I know that this statement is not in accordance with the practice of some other concerns; but after having used the coarse feeds on work that was going to the grinder, covering a period of six months and tested out carefully, and comparing the results with those secured with a higher speed and a finer feed, we find the latter to be preferable. Moreover we can get closer to the exact diameter required, leaving less work for the grinding machine than when we used very coarse feeds.

We have been making some experiments on our drill presses with the high-speed steels and find that the most astonishing results may be had by taking flat drills in Novo steel and on account of the high speed possible do much more rapid drilling. The flat drill will do its work nearly as well as the twist drill if care is taken to have the cutting points ground with the same nicety that we would grind the cutting points on a twist drill, and, except in cases where blow holes are met with, we believe we are going to find great advantages in using this steel either for flat drills or straight grooved drills made from round stock. On planing work there is no difficulty at all in having tools stand for roughing operations up to 55 feet per minute, and even more than this on light cuts for finishing. In the matter of finishing cuts it depends a good deal on the piece as to the advisability of using a higher or lower speed; but we get very good results at highest speeds on finishing cuts, and the same thing holds good on lathe work.

We have recently been trying some rather interesting experiments on heavy tools by brazing flat pieces of high-speed steels on to machine steel; and as this steel is so exceedingly costly and particularly for heavy planer tools and heavy lathe tools, it might be wise for our members to look into this feature of economy. I shall be glad to show quite a number of these tools fixed in this manner. Of course, much higher speeds may be used in planing where the cuts are intermittent than where they are continuous or where the piece being planed is short. We also find that it is quite possible to use the Novo as a steel for finishing—for instance, as "V" thread chasing and at rates of speed never dreamed of in our old shop practice. It is our experience, and I judge the experience of nearly all other machine shop owners, that the tendency on the part of the men is to use as fine feeds and as low speeds as the man in charge will permit, and we find that the substitution of the premium system of doing work is of greater value in this particular than close superintendence or increased wages as applied to the regular daily rate.

CRUSHED STEEL AND STEEL EMERY.

Abstract of Paper read by M. M. Kann before the American Society for the Advancement of Science.

The author states that crushed steel is a well-known artificial abrasive which dates back its origin about fifty years. It was first used in some German industries where a harder cutting material than emery or corundum, was required. Resort was made to broken files, but the product was an expensive and uncertain abrasive on account of the difficulty in getting uniform fracture and shape of grain. Reference was made to the organization of a company for the regular manufacture of

crushed steel in the United States. The Pittsburg Crushed Steel Company was organized in 1889 and after a vast amount of experimental work they were able to produce an artificial abrasive in uniform grains, structure and sizes, of the required hardness and toughness, and at a cost that enabled it to be placed on the market in competition with natural abrasives like emery and corundum.

This abrasive is manufactured preferably from pieces of high-grade crucible steel, heated to a temperature of about 2500 deg. F. and then quenched in a bath of cold water or other suitable hardening solution, which gives the steel a granular structure. The pieces are placed under powerful hammers or crushing machines, and are reduced to small particles, varying from fine powder to grains of many different sizes. The steel particles are then tempered, preferably in a cylinder or pan and heated to a temperature of about 450 degrees, F., until the particles change their appearance to a straw color; they are then cooled by being subjected to cold air in various ways. The material at this stage, or before the tempering process, is graded into many sizes, according to the number of mesh openings of the sizing screen per square inch. The sizes of diamond "crushed steel" run in numbers from No. 5 to No. 60 inclusive. Diamond "steel emery" is similar to crushed steel, but it is given an intensely hard temper, and its numbers range from No. 60 to No. 200 and above. These two abrasives, so closely related to each other, are used for entirely different purposes in the various trades. Crushed steel and steel emery rank very close to the diamond in hardness, being 9.27 if the diamond is taken at 10.

Crushed steel is tempered mostly to a tough hardness, while steel emery, having different work to perform, is made intensely hard. A grain of crushed steel, examined under a magnifying glass, exhibits a series of sharp points and cutting angles. In work, as fast as the point is worn down another is presented, while should a grain break it presents on the fractured face a multitude of new cutting points.

Crushed steel and steel emery are now used in the sawing, rubbing, and polishing of stone, marble, granite, onyx, etc., in lens grinding, glass beveling, brick grinding, and by lithographers, engineers, and plate-glass manufacturers. If a bond could be found, so that these steel abrasives could be placed on the market in the form of a wheel or brick, the length of the above list would be much extended.

After referring at some length to the various uses to which crushed steel and steel emery are put, which practically covers all abrasive operations except those requiring a solid material like grindstones, emery wheels, etc., the author states that engineers are finding out the value of this abrasive, which "cuts but never breaks." In grinding metal, the work which steel emery will do is considerable, and now all important railroads in the United States and Canada consider it an indispensable material in their shops. Hardened tool steel, against which emery instantly pulverizes, and which will resist the bite of a file, yields to the cutting power of these minute grains.

Lack of acquaintance with steel emery may lead the workman to believe that it has ceased to cut long before its power is exhausted. This is due to the absence of the peculiar grating sound produced in its operation, now deadened by the minute particles of abraded metal, which thicken the oil and so prevent the steel emery from doing its work properly. The addition of a little oil permits the grains of steel to move freely and new life is given them. In ordinary grinding and on flat surfaces steel emery is used in precisely the same manner as ordinary emery, but special care must be exercised in its use, because the grains of steel emery are so much smaller than the abrasive heretofore used for the same purpose. Oil must be applied sparingly to prevent the steel emery being drowned or floated away. On curved surfaces, or where there is a double seat, one above the other, it frequently happens that a lateral "dishing" or swinging movement cannot be given. Where such surfaces are to be ground, the work should be frequently lifted, so as to prevent grooving.

THE ARNOLD ELECTRIC-PNEUMATIC RAILWAY SYSTEM.

Western Electrician, May 2, 1903. p. 345.

The electro-pneumatic railway system invented by Bion J. Arnold, of Chicago, has been subjected to practical tests with gratifying success and is soon to be installed on a twenty-mile line in Michigan, the Lansing, St. Johns & St. Louis Ry, which has been built on private right-of-way and closely approximates standard steam railroad practice, and which it is expected will eventually be extended to St. Louis.

The general features of the Arnold electro-pneumatic system were given to the public in a statement presented by Mr. Arnold bfore the annual meeting of the American Institute of Electrical Engineers at Great Barrington, Mass., last June. (See MACHINERY, August, 1902.) Briefly considered, the invention consists of the use of a single-phase (or, if desired, other alternating-current) motor, operating at constant speed under constant load, the acceleration and retardation of the motor being accomplished by means of compressed air. The single-phase motor with which each car is equipped has both its armature and its field capable of revolution about the common shaft, either separately or together. An engine capable of compressing air is attached to the armature and a similar one to the field, and both are connected to an air-storage reservoir on the car. Each of these engines is also capable of driving, by means of the compressed air, that portion of the motor to which it is connected. Under normal running conditions the field magnet is at rest with respect to the car, and the armature, which is connected to the car wheels, rotates at its constant speed. Slowing down the motor is accomplished by releasing the clutch which holds the field motionless. The field begins to revolve and the field engine starts to compress air. As the speed of the car is decreased the rotation of the field is increased, and when the car is stopped the armature, of course, comes to rest, but its relative speed, with respect to the field, is maintained constant, and the field engine continues to store compressed air in the reservoir.

In starting the car the operations are practically reversed, the field engine being throttled, and, in addition, the armature engine is connected with the air reservoir and aids the armature in coming up to speed. Speeds above normal are secured by actuating the field engine by compressed air, the actual speed of the field being added to the synchronous speed of the motor. In ascending a grade the natural capacity of the motor is increased by the armature engine, and in descending a grade the energy of the motor may be entirely converted into energy of compressed air.

The signal advantages to be derived from such a system may be briefly stated as follows: The motor, operating at constant speed under constant load, will always work at maximum efficiency. The customary variations at the power house will be considerably decreased, as the different motors on the road will always carry the same load. By the use of the alternating current motors the elaborate and expensive system of rotary-converter sub-stations will be done away with, thus effecting a great saving in installation and maintenance. The energy now wasted in braking and in descending hills will be stored up for future use. Other advantages are the operation in towns and for switching by means of the pneumatic power alone, and the use of a high-tension, single-phase current with a rail return.

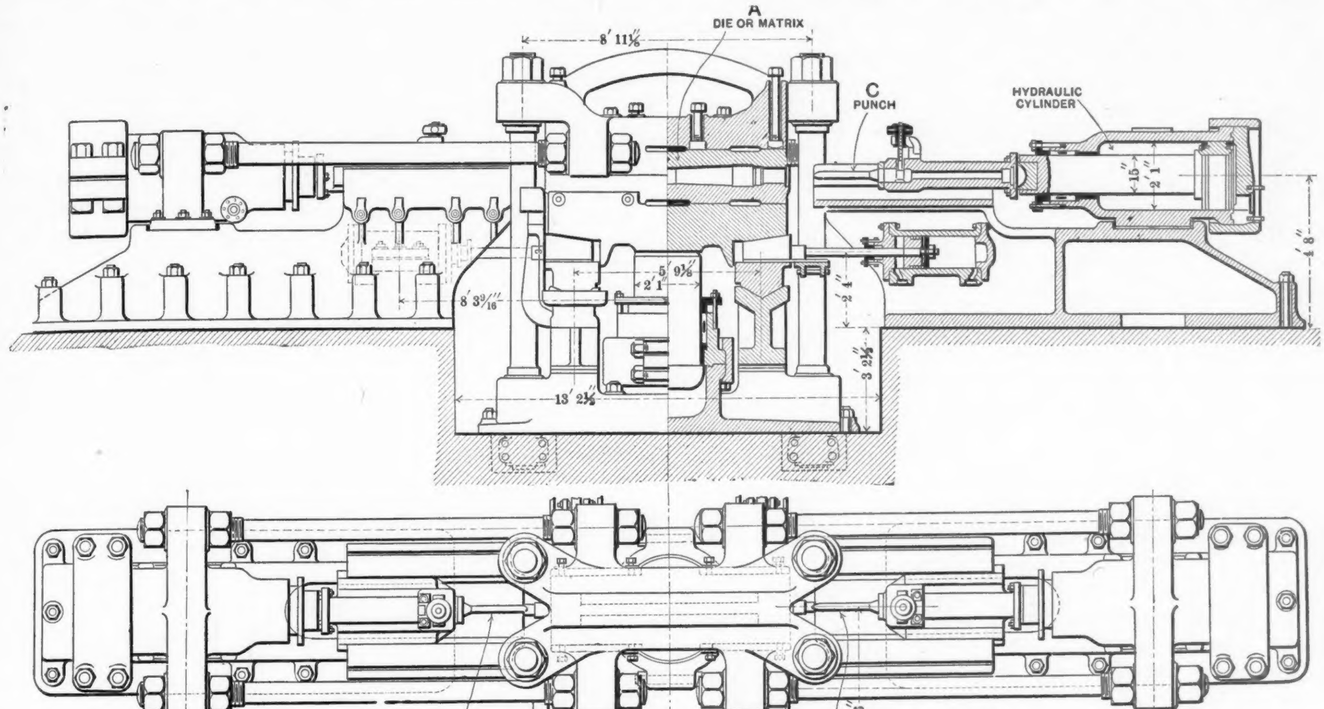
The Lansing road uses a 15,000-volt current on the line, and this potential is stepped down on the car to 200 volts, the working voltage of the motors. In passing through large cities the working voltage on the line may be reduced to the working potential of the motor by a stationary transformer, placed at the limits of the city.

HOLLOW PRESSED CAR AXLES

Abstract from Paper read before the May meeting of the Iron and Steel Institute by Camille Mercader. (London, Eng.)

The paper is an interesting exposition of the modern tendency to form iron and steel parts required to be made in large quantities, by heat and pressure rather than by cutting operations. It describes a method followed at the Carnegie Steel Co.'s works at Homestead, Pa., in the manufacture of hollow pressed car axles, which is one developed at the suggestion of the author. A rolled steel blank, uniformly heated, is inserted in a two-part die, *A*, Fig. 3, having a matrix cavity of the shape of a rough-turned axle. The diameter of the journals is made equal to the smallest diameter of the axle in the center, which also equals the

diameter of the round blank. After the dies are clamped about the heated blank the latter is axially perforated simultaneously at both ends by two cylindrical punches, which force the metal of the blank to conform to the shape of the matrix die and fill out the same. The blank is heated up to 1,800 degrees F., and the total hydraulic pressure required for penetration with a punch of 3 inches diameter amounts to about 50 tons. During the last end of the stroke a total hydraulic pressure of about 150 tons is required because the blank loses its initial heat through contact with the dies and because the end collars upset, at which time the metal may flow back against the punch. The punch, being tapered, acts as a wedge and the pressure that can be exerted upon the axle blank is consequently enormous. To prevent the punches becoming overheated by contact with the hot metal, water circulation is provided, the punches being made hollow for the purpose.



Figs. 1 and 2. Hydraulic Press for Forming Hollow Steel Car Axles.

This great compression improves the quality of the steel in the central part of the axle by destroying the injurious effects of segregation and piping usually found in ingot steel. It is absolutely necessary to have the greatest possible uniformity of heat throughout the body of the blank, the temperature determining the resistance which the punch must overcome.

The advantages of a hollow pressed axle may be summarized as follows:

1. The axle has a perfect form; its shape can be best adapted to resist the strain to which it is subjected with the least amount of metal, combining minimum weight with maximum strength.

2. The forging effect being carried out throughout the material, both internally and externally, the material is found to be far more homogeneous than solid axles made in the usual manner; segregation is destroyed, and, consequently, the axle is much more reliable.

3. The journals being highly compressed, will in finishing, attain a more highly polished surface, thereby minimizing the friction, resulting in economy of draft.

4. The journals, being hollow, will remain cooler and permit the storage of a considerable quantity of oil, removing herewith the chief cause of hot journals, also economizing materially in the expenditure for lubrication.

5. No straightening after punching is required, the axle being as straight as the die, thereby eliminating entirely the injurious effects of the gagging operation.

6. No centering, no cutting of the ends, no rough turning is required, thereby saving considerably in finishing labor and increasing the finishing capacity of existing plants.

7. The punching of treble the amount of axles as compared with forging with an equal number of hands, resulting in saving of forging labor.

8. The detection of a defective axle without performing any extra work—that is, without the necessity of rough-turning it over all, which provision is now included in the latest M. C. B. specifications.

9. Approximately uniform fiber stresses throughout the body of the axle, due to the straight and uniform taper between the wheel seats.

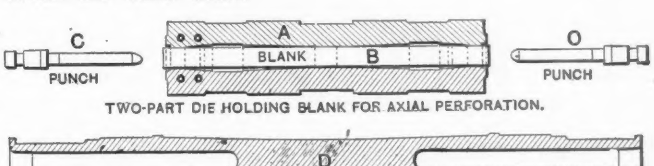


Fig. 3.

10. A saving of 33 per cent. of steel in the manufacture.

11. The weight of a 100,000 pounds capacity steel car is decreased by 1.7 per cent., permitting this load, which amounts to 24,000 pounds in a train of 40 steel cars, to be carried without any additional expenditure of energy.

HEAT TREATMENT OF WHITE-IRON CASTINGS.

Abstract from Paper read by A. E. Outerbridge before the Annual Meeting of the American Society for Testing Materials, held at Atlantic City June 12-14, 1902.

In the year 1882, while engaged in metallurgical work at the car-wheel foundry of A. Whitney & Sons, in Philadelphia, my attention was called by the inspector of wheels to an unusual and remarkable change that had occurred in the chilled or

white iron forming the "treads" of a number of wheels poured from one heat. This change was first observed on removing the wheels from the annealing ovens. It was customary for the inspector to prove the hardness of the chilled treads by testing them with a cold chisel all around the "throat" or place where the tread joins the flange. On this occasion he found a number of wheels which were quite soft on one portion of the rim, extending the entire width of the tread for a length of 6 or 7 inches, while on either side of the soft spots the chilled tread was so hard that the steel chisel slipped over the surface without biting. In order to study the nature of this singular occurrence I caused the wheels to be broken through the soft spots so as to examine the fracture, and I found that the white iron (chilled iron) had been changed into perfectly gray iron, evidently after the wheels had been cast. The change was not equally well marked in all of the wheels and the soft spots were smaller in area in some cases than in others, but in all, the dividing line between the white portion and the gray portion of the chilled tread was sharply defined.

It is perhaps necessary to state that in the establishment where these wheels were cast it was customary to pre-heat the annealing pits by means of soft-coal fires before the wheels were lowered into them, the flames passing through the pits or ovens. The rule was to close the dampers just before the pits were opened to receive the red-hot wheels, in order to shut out the flames.

After careful investigation, I found that through an oversight the dampers of the annealing pits had not been closed and the flames from the fires impinged upon the surfaces of three or four red-hot wheels in the lower part of each pit, causing a complete change of the carbon from the combined form to the free condition wherever the flames touched the castings.

Specific gravity tests showed that the gray cast-iron resulting from this accidental heat treatment of white iron differed materially in density from the normal gray iron forming the unchilled parts of the same castings; the specific gravity was about 7.80 as compared with specific gravity of about 7.20 for the normal gray metal; a cubic foot of the gray iron produced by this annealing process therefore weighed about 37.5 pounds more than a cubic foot of the normal gray iron of the same casting. It was noticed that the fracture was of much finer grain than normal gray iron, and "chips" or drillings of the annealed chilled iron differed greatly in appearance, size and shape from the chips or drillings of the normal gray iron made with the same drill.

Several metallurgists, to whom the pieces of annealed chilled iron were exhibited, offered a plausible explanation of the phenomenon, saying that it was merely an accidental conversion of the white iron into malleable iron, and therefore presented no novel features. The analyses quickly showed the fallacy of this theory, for the total carbon was the same after annealing as before annealing, being about 3½ per cent. in each case, while in the ordinary conversion of white-iron castings into malleable iron, a large part of the carbon is removed by the oxidizing material in which the castings are imbedded when subjected to heat-treatment, and this conversion of white iron into malleable iron can only be successfully accomplished on sections of metal of moderate thickness, say less than 3 inches.

Although this accidental discovery of annealing of white iron on the treads of car wheels was regarded as an interesting and novel one at the time, the only practical use made of it was to guard against a repetition of the accident in the annealing pits of the car wheel works with which I was at that time connected.

After the lapse of several years I was called upon to investigate in a professional capacity, and in the interest of some prospective investors, the merits of a new process of converting white-iron castings into steel, and received from the manufacturer a number of axes, hatchets and other edge tools, which had been cast in white iron and subsequently converted into a metal having evidently many of the qualities of steel.

Without describing in detail the process to which these white-iron castings had been subjected, I may say, briefly, that they were placed in the muffle of a furnace together with a chemical compound claimed to be necessary to the conversion of the cast iron into steel. Common salt and crude hydrochloric acid were two ingredients of this compound. The similarity between this process and the accidental over-annealing of the car wheels (with consequent change of the condition of the carbon) suggested to my mind that the chemical compound was probably unnecessary and that the secret consisted solely in the heat treatment, and I so advised my clients.

The conversion of white-iron castings into dense gray iron having high strength (approximating that of certain grades of steel) capable of being hardened and of taking a sharp cutting edge is no longer a secret, and is carried out on a commercial scale in a number of establishments. While I cannot speak positively, I am of the opinion that the heat treatment alone is now relied upon to produce the desired results. These products are not steel castings, though sold in some instances under the name of steel; neither are they malleable iron, but they may be described as occupying a peculiar position midway between cast steel and cast iron.

Although it is a misnomer to call castings, such as hatchets, axes, etc., made from white iron changed to gray iron by heat treatment and subsequently hardened on cutting edges, steel castings, they are certainly very different from true malleable iron castings or from ordinary gray iron castings, possessing qualities more closely resembling steel. If we can eliminate the false name of "steel" which has been given to converted white iron castings, a distinct advantage will have been gained, for I believe that the new metal is worthy of taking a special place in the metallurgical arts, and I anticipate extended practical applications of the process as knowledge of the proper methods of heat treatment and of the valuable properties (as well as the equally marked limitations) of the metal shall become better known and appreciated.

* * *

TEXT BOOKS.

In a circular issued to the alumni of the Massachusetts Institute of Technology, with reference to various matters connected with that institution, is a paragraph upon text books which expresses an idea that will be appreciated by all who have occasion to use works of reference on engineering subjects.

"Text books are largely unsatisfactory. While they may be written by men who have knowledge of their subject, their authors usually have but little experience in the presentation of the subject or the systematic arrangement of a book. As a result we have many books with good subject matter poorly presented, some so poorly as to render them of little value as works of reference. It would seem that a very important function of any school, especially of a technical character, would be to provide the best sort of tools for its students, and it is suggested that no more important branch of any such school could exist than one systematically taking care of the preparation of proper text books. A systematic handling of this text book matter would be of value, not only to students, but to graduates or engineers. To show that this point is of value, we cite the case of the International Correspondence School, at Scranton, Pa. This school was started in 1891 with a capital of $12,000, and now has a capitalization of $3,000,000. A large part of its success comes from its systematic text books, treating in a uniform, clear, concise, and very simple manner the various subjects which it gives. It offers something over one hundred courses, and has prepared text books for them all. The text writers of these books are not men of note, and yet the books are of value to men in their profession on account of the uniform and systematic treatment. We have only to point out how great is the value of text books written by men most eminent in their profession and edited in a systematic manner."

* * *

One thing about the heavy, high-speed, high-powered automobile that recommends itself to the traveling public, is that it is undoubtedly the best vicious dog killer ever invented. The dog who gages his provoking antics to the pace of the ordinary horse-drawn vehicle, is totally unprepared for the speed of the automobile and often before he knows it he is rolled ignominiously in the mud—usually with serious results to his dogship.

THE INSPECTION DEPARTMENT OF THE GARVIN MACHINE CO.

The inspection department and stock room of the Garvin Machine Company, New York, covers a space 30 x 81 feet on the north side of the second floor of their eight-story machine shop at the corner of Spring and Varick Streets. The half-tone, Fig. 1, shows the stock clerks' desks, the inspectors' benches and a portion of the stock racks. Fig. 2 is the floor plan. It will be observed that the arrangement is such that the work for inspection enters at the receiving window, or door, passes the inspectors' benches and then goes either to the stock racks or to the delivery. All work that is of a size that it can be conveniently handled, such as gears, cams, disks, pins, screws, studs, collars, spindles, dials, brackets, collets, shanks, index plates, centers and the thousand-and-one other small parts that go to make up the construction of the variety of machinery built here, passes through the inspection department at least once, and in some cases two or three times. This latter, of course, applies to such parts as require a series of operations, the accuracy of each of which depends upon the preceding one. The larger parts such as frames, tables, etc., are inspected on the shop floors wherever they may be located, and the assembled machines are inspected at various stages of the assembling and when completed, on the erecting floors.

Inspection is interpreted to mean something more than mere measurement and gaging of parts: they must pass a certain standard of finish and general appearance which, of course, is well within the province of the department. The "personal equation" is also recognized, as it must always be in any human institution; machine parts finished by men of good mechanical standing may not in all cases be subjected to the searching investigation given the work of the party who has the reputation of "letting things slide." While it might be argued that in a well-appointed shop there should be no room for a representative of this class, the practical difficulties of getting first-class machinists in large cities make it imperative to keep some of them. The work can then only be kept up to a high standard by close inspection and "firing back" such parts as do not fulfill the standard requirements in every particular. So prone is this class to overstep the limits allowed that they (the limits) have in many cases been made closer than really necessary for commercial work. Thus if the requirement of accuracy for any part should necessitate its being within 0.003 inch the shop limits would be set at, say 0.002 inch, which condition gives the inspector a chance to exercise some discretion in the matter of passing work. In case any part is passed in which appears a minor defect that in no way injures the working of the machine, the fact is noted and a record kept along with the record of tests.

The inspectors' benches are equipped with long surface plates which are provided with T-slots the same as a milling machine table. In fact, the plates are tables that have been adapted for this purpose. Such parts as dividing heads are set up on these surface plates and tested with reference to the top surface of the plate, and to the positive side of the middle T-slot. The parts of a dividing head have all been inspected separately before it goes to the inspection department in the assembled form. The taper hole is again inspected for fit of the taper center, a test bar is put in to test the running of the taper hole and for parallelism in a horizontal direction when the head is set at zero, and then it is tested sidewise from the positive side of the T-slot. The alignment of the head and foot stock centers is tested to determine their accuracy. The spindle is set perpendicular to the base of the head to determine the accuracy of the graduation and its relation to the main spindle.

Fig. 1. General View of Inspection Department of the Garvin Machine Co.

When these tests have been concluded an accurately cut disk about 8 inches in diameter, having 40 teeth and mounted on a taper mandrel, is applied, the mandrel being slipped into the spindle hole. The test indicator is set to the positive side of one of the teeth on the horizontal diameter so that the pointer stands at zero. The handle is then revolved once, thus turning the disk one division. The test indicator is then applied and the reading taken. The opera-

tion is repeated for each tooth and the readings recorded on special sheets prepared for the purpose. When the error is in one direction it is marked +; in the opposite direction, —. The arithmetical sum of two greatest deflections from zero, + and —, are recorded as the error of the head. Thus, if the reading at starting is 0; at the tenth division, + 0.0015 inch; at the twentieth, 0; and at the thirtieth division, — 0.0015 inch, the total error would be 0.003 inch.

It would be an interminable and most difficult job to test the accuracy of the holes drilled in the index plates, and it is not attempted. The method of producing them and the fact that any error of spacing is reflected in the movement of the dividing head spindle in the ratio of 1 to 40, so that it would require a serious error in the index plate to produce an appreciable error in the spacing of the spindle, are taken into consideration. The index plates are drilled under a sensitive drill press, using a Brown & Sharpe master plate for indexing. The drill is guided by a bushing in the manner described in the April, 1903, issue. The master plate is made of considerable thickness, but the indexing pin enters it only a short distance. At such a time that it is found that wear of the master plate has affected its accuracy, it is removed and the surface faced off, leaving a series of sharp-edged unworn holes for the index pin, which is then set further up to engage with them. This, of course, restores the original accuracy to the device. This is mentioned as an instance where absolute inspection is both unfeasible and unnecessary because of the method of manufacture and the relation of the piece to action of the machine.


INSPECTOR'S NOTICE.

Finished and inspected 5/14/03

Name of Mche. 5 Index Center

Made on Order No. 8458

Mche. serial No. 97

Where located when inspected 2nd

Inspector.

How disposed of 67/

Stock Clerk.

Fig. 3. Specimen Inspector's Notice.

In the April issue mention was made of a combination boring machine for boring the holes in milling machine frames at one setting. The accuracy of this machine has an important influence on the product, and the fact that it does produce accurate work makes the alignment of the spindle, overhanging arm and knee a comparatively easy matter. Inspection is made after the holes are bored, and if found "out" the error is corrected by scraping the holes in the boxes and the front surface against which the knee is clamped.

The assembled machines are tested for alignment with the the following limits allowed in the case of plain milling machines: Alignment of knee with spindle in horizontal and vertical planes, 0.003 inch in 14 inches; top of table with spindle 0.0015 inch in 5 inches; slot in table at right angles to spindle 0.003 inch in 30 inches; ways of table with slot 0.001 inch in 12 inches; overhanging arm with spindle 0.002 inch in 14 inches; outboard bearing with spindle 0.002 inches high or low.

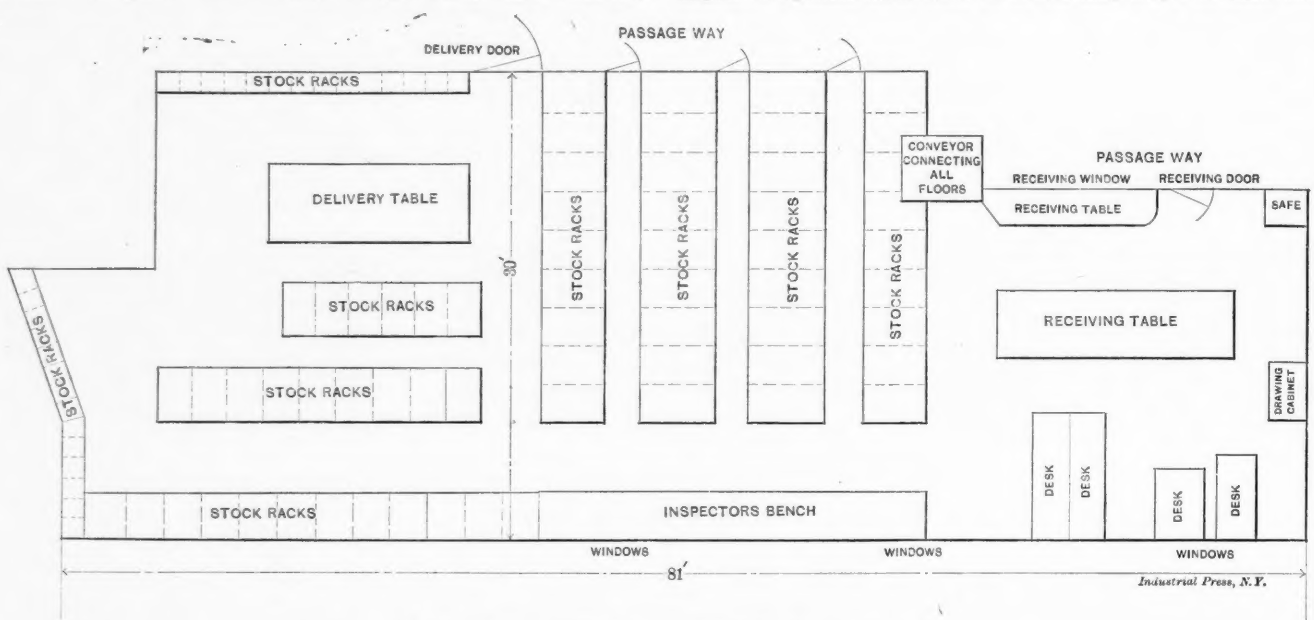


Fig. 2. Plan of Inspection Department, Garvin Machine Co.

In regard to keeping the shop gages accurate the chief inspector says that the men largely take the initiative in seeking that the gages be corrected, if they have reason to suspect them worn sufficiently to be inaccurate. Of course, it is to the self-interest of every employee that the gages he uses are right; otherwise he will be responsible for a lot of defective work which he must make good. It thus appears that under a moderately rigid inspection system the correction of the shop gages is largely automatic, in the sense that the men act as their own inspectors in this regard.

* * *

The National Machine Tool Builders' Association, at their October, 1902, meeting in Cleveland, O., passed a resolution to hold the next meeting at Worcester, Mass., in April, of the following year. As many members of this Association are also members of the National Association of Manufacturers and of the Metal Trades Association whose conventions took place in April, it was decided to postpone the meeting of the National Machine Tool Builders' Association. This convention, it is officially announced, will be held on Tuesday, June 9, at Worcester, Mass.

* * *

In his book, "The Great Siberian Railway from St. Petersburg to Pekin," Michael M. Shoemaker makes a curious statement regarding American locomotives which he saw near Port Arthur. "As we were moved around the yards I notice a very familiar sound to the locomotive, which I find is one from the Baldwin Works in Philadelphia—poor specimens of American engines; certainly not such as the Balwin Works are in the habit of turning out." Probably Mr. Shoemaker does not realize how essential to the life and well-being of a locomotive, is good care. Judging from what he says of the average Russian in his book we should not expect the Russian engineer to keep his engine in very excellent shape. It is absurd to blame the builder for the bad appearance of his product which is in the hands of presumably careless and untrained men.

ILLUSTRATIONS* OF THE VARIOUS USES TO WHICH A MODERN SAW BENCH CAN BE PUT.

I. MC KIM CHASE.

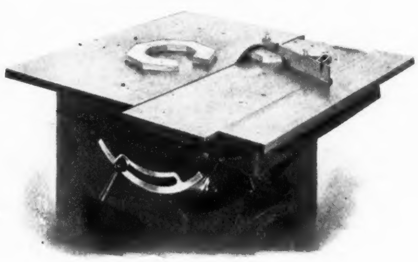
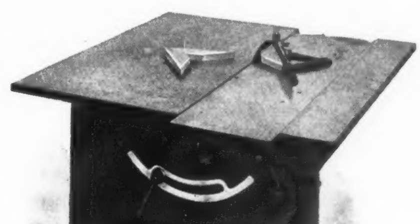
In consequence of the diversity of pattern work the machines usually found in woodworking establishments for doing one particular kind of work are not well adapted for use in pattern shops. The most useful machines for the pattern shop are those that will admit of various kinds of work being done on them. A patternmaker will use a machine some minutes to do a part of a piece of work he is engaged upon. Another workman will follow him with work requiring the use of the machine in quite a different way. Within the past few years several machines have appeared on the market specially designed for use in pattern shops that will admit of them being used in a variety of ways. Not the least important of these holes provided for the dowel pins so that the fences may be set at various angles. To illustrate the various settings possible on some up-to-date machinery the accompanying cuts are largely self-explanatory.

Fig. 1 shows the top of the bench arranged to cut the segments required to form an octagon.

Fig. 2 shows the arrangement for cutting the segments for a triangle. By setting the fence at the required angle, for which holes are provided for the dowel pins, all of the most important angles may be cut, such as miters, angle to form pentagon, hexagon, etc. (See Figs. 8 and 9.)

Fig. 3 shows a special fence and gage for sawing the ends of segments for circular work. Every patternmaker can appreciate this handy device, as by its use the building up of segment work can be expedited.

Fig. 4 shows the top of the bench tilted and arranged to

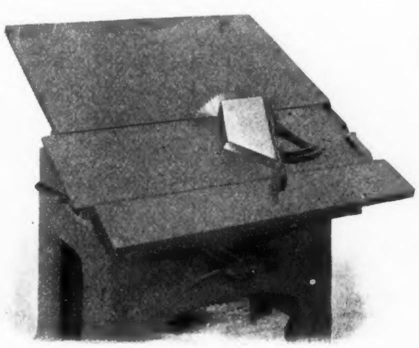
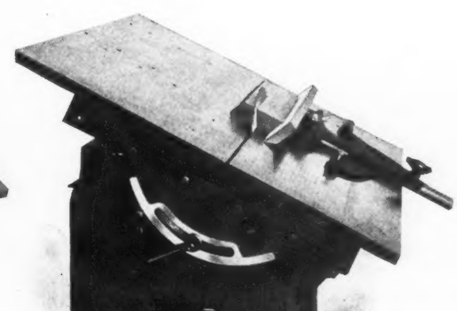
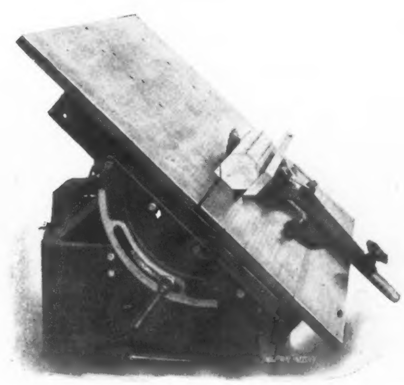
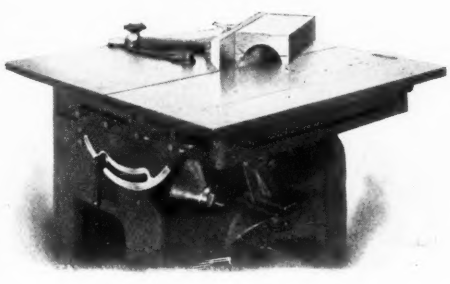





Fig. 1. Sawing Sections for Octagons.
Fig. 4. Sawing Compound or Flaring Angles, such as the Sides of Trays, Etc.
Fig. 7. Sawing out Round Core Boxes.
Fig. 2. Sawing Sections for Triangles.
Fig. 5. Sawing Bevels for Cylinder, Column and Similar Patterns; also Cisterns, tanks, Etc.
Fig. 8. Sawing Sections for Hexagons.
Fig. 3. Sawing Segments for Pattern Work.
Fig. 6. Sawing Newel Posts, Etc. Table can be tilted to square, octagon, hexagon, etc.
Fig. 9. Sawing Miters for Square Frames, Etc.

machines is a combination saw bench. These benches have two circular saws, a crosscut and a rip saw. The arbors of the saws are journaled in a revolving frame and by means of worm gearing either saw may be raised above the top of the table to make any desired depth of cut that the diameter of the saw will allow. This makes the machine convenient for cutting grooves, roughing out plain, round core boxes, and similar work. Another important feature embodied in these machines is a slide which forms a part of the top and to which the fences and guides are attached by dowel pins.

The tops of these benches are usually graduated and have

*The illustrations accompanying this article were made from photographs of a saw bench manufactured by the Colburn Machine Tool Co., Franklin, Pa.

cut compound or flaring angles, such angles as required for the sides of trays, hoppers, etc.

Fig. 5 is the arrangement for cutting staves for cylinders, large core boxes, etc.

Fig. 6 shows how the top may be tilted and, in combination with the fence, any shaped prism, such as square, triangular, hexagonal, octagonal, etc., may be cut.

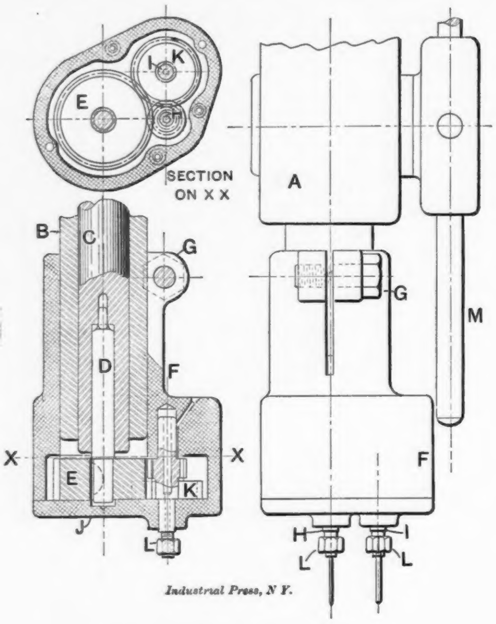
Fig. 7 shows the arrangement for performing a very important job, and one frequently required in making patterns. It is that of working out the inside of a plain cylindrical core box. The angular position of the work relative to the saw, and its line of travel, produce a close approximation to a semicircular concaved shape which can be afterward trued up with the core box plane with a minimum of labor.

LETTERS UPON PRACTICAL SUBJECTS.

A DUPLEX DRILLING ATTACHMENT.

Editor MACHINERY:

An operation that is carried on continuously, day after day, and week after week, will well repay the cost of tools a little more elaborate than those required for occasional work. The illustration represents an arrangement for drilling two holes at once on repetition work of this kind. The piece to be drilled is a chain link used in a certain class of textile machinery and has two holes, about 15-16 inch apart, which are respectively .050 and .100 inches in diameter



A Duplex Drilling Attachment.

A is the adjustable head of a sensitive drill and *B* the sliding sleeve carrying the spindle *C*. To the taper hole in the end of the spindle is fitted the shank *D* which drives, through a key, the large gear *E*. *F* is a brass casting which encircles the sleeve *B* and is clamped thereto by the bolt *G*. This casting is provided with bearings for two small spindles, *H* and *I*, whose lower ends are supported by the brass cover plate *J*, which is screwed and doweled to the main casting. The spindle *H* is driven, from large gear *E*, by a pinion made integral with it, while spindle *I* is driven by the pinion *K*, keyed to it and also meshing with the gear *E*. The diameters of these two pinions are so proportioned to the driving gear that each drill is given a speed suitable to its diameter. The spindles are bitted out to fit the drills, which are held in the split ends by screwing up the nuts *L* on the tapered thread. The mechanism is entirely covered so as to be free from flying chips, and ample provision is made for oiling. The motion of the spindle *C* must, of course, be reversed in order to use right hand drills. The feeding is done as usual, by the pilot wheel *M*.

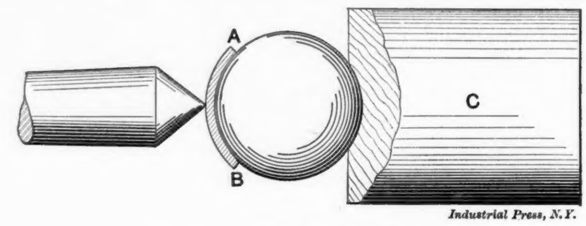
R. E. F.

TURNING A BALL.

Editor MACHINERY:

To make a ball as nearly perfect as a billiard ball is not a piece of work that a machinist or patternmaker has often to contend with, but sometimes there is a necessity for such work. There are several cases in which ball valves are used, such as in pumps where chips, dirt, or sawdust are liable to get under the valve seat, or in tannery works where small pieces of bark are apt to be mixed with the liquid. The rolling action of the ball has a tendency to remove the obstructions and let the valve seat fairly. Costly machines have been made for the purpose of turning balls, but the method here described is capable of producing just as good results on an ordinary lathe.

To make the pattern of the ball, first turn the piece on centers, using the calipers to get it somewhere near to the shape. Then cut off the centers and make a chuck block, of hard wood, as shown at *C* in the sketch. This is cupped to suitable shape to take in a small section of the ball. For the outer support use a blunt wood center, or an ordinary steel center with a strip of copper between the point and the work. Put the piece in the chuck so as to take the first cut around in the direction of its first centers. Take just a light chip, a narrow ribbon, and do not try to turn a wide space. Having turned it round in this direction, change the chuck so as to



Arrangement for Turning a Ball.

make another turning at right angles to the first, using the first cut as a guide to the depth of this second turning. Then change the work so as to make a turning between these cuts and continue to change it around until the entire surface has been turned, when it will be a perfect sphere. When it comes to finishing up the casting, bolt the chuck block to the faceplate and use the regular tail center with a concave piece of copper, as shown at *AB*. Use a hand tool or scraper after getting under the scale.

R. B. OTIS.

Leeds, Mass.

A COMBINATION PUNCH AND DIE.

Editor MACHINERY:

The cuts on the next page, Figs. 3 and 4, show a combination die and punch that is used for cutting out, bending, perforating and ejecting from the press such an article as is shown in Fig. 2. This is a plate, 6 inches by 4¼ inches, with the sides ¼ inch deep, bent over at right angles with the face of the plate. It is made of aluminum, brass, or tin, and forms the back part of a metallic picture frame.

In operation the outside cutting edge of the punch comes in contact with the inside cutting edge of the die, thereby cutting out the blank shown in Fig. 1. The punch, then continuing its downward travel, forces the blank over a forming plate, which is fastened to the inside of the die, so as to bend the sides to their proper shape. At the same time two small punches perforate the holes in the back of the plate. The punch then rises and the finished product is ejected from the press by a set of knock-out devices.

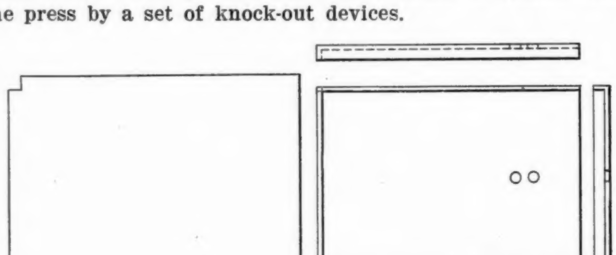
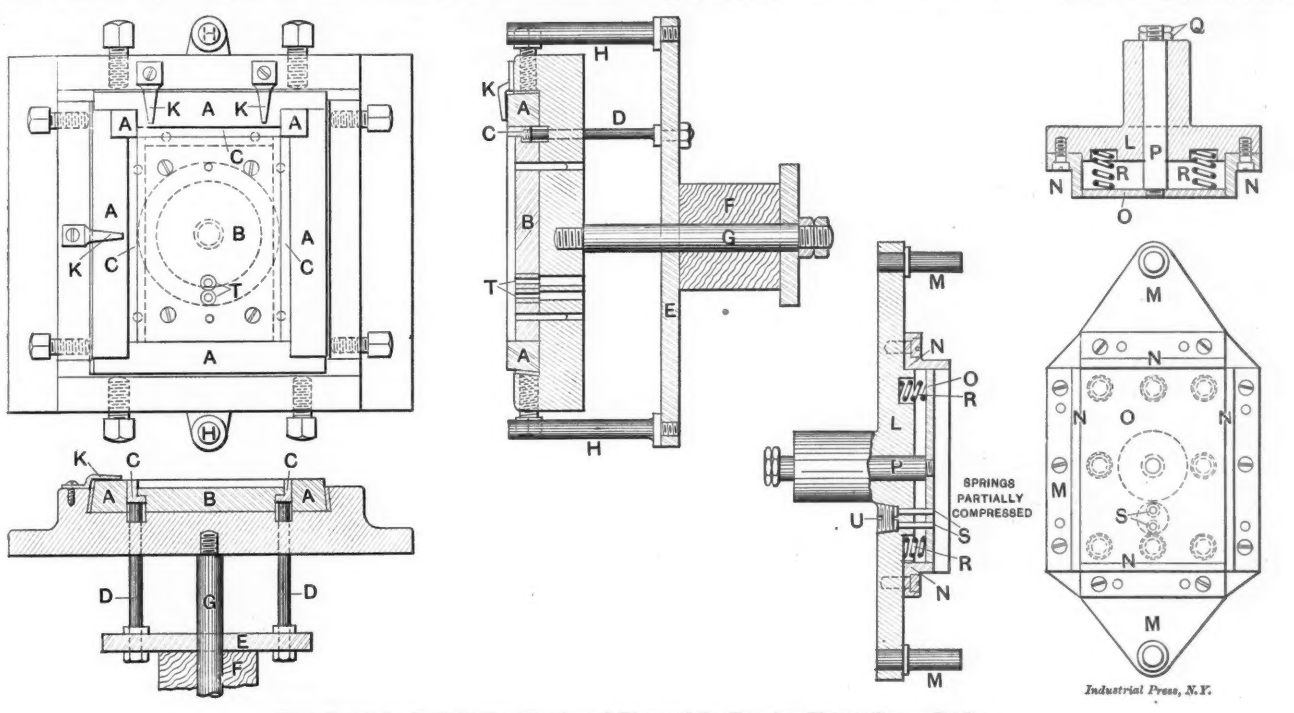


Fig. 1. The Blank. Fig. 2. The Finished Piece.

Fig. 3 represents the die or bottom part of the mechanism. It is composed of a cast iron or steel shoe, or bolster, the sides of which are beveled out on the inside at an angle of about 10 degrees. Held within this shoe are six tool steel sections, *A*, *A*, which form the cutting die. These are hardened and ground all over and when put together the space between the cutting edges is of the exact shape of the blank, Fig. 1, allowing no clearance on the inside of the cutting die. The four outer sections are beveled at an angle of 10 degrees, corresponding with the bolster, and thin strips or liners are inserted between the dies and the shoe, the whole being locked tightly by means of setscrews. The die sections project ¼ inch above the top of the bolster to allow for grinding the die. A tool steel forming-plate *B* of the size of the inside of the plate is fastened to the inside of the bolster by means of flush

head screws and dowel pins. This is ground all over and the upper edges are slightly rounded off with an oil stone to prevent cutting or scratching of the plate. Between the forming plate and the inside of the die are the three L-shaped pieces *C, C, C*, which form the knock-out mechanism. They are connected by the bolts *D, D*, to the plate *E*. Beneath this plate is placed the rubber spring *F*, which is held to the central stud *G* by a washer and check nuts. At the ends of the knock-out plate are two vertical studs, *H, H*, which are of sufficient length to come up even with the top of the die. As the punch descends it encounters the tops of these studs and forces down the knock-out plate and with it the L-pieces, thereby drawing them out of the way of the part of the blank that is being bent over. As the punch rises and the pressure on the rubber is released these pieces rise and eject the finished work from the die. Three steel gages, *K, K, K*, are fastened to the top of the shoe and are bent over the top of the die to within 1-16 inch of the cutting edges, thus forming a gage for the material as it is placed in the die.

The punch, which is shown in Fig. 4, has a soft steel punch holder, on the front and back ends of which extend flanges of sufficient length to bring the studs *M, M*, opposite the studs *H, H*, in the knock-out plate of the die. The center of the face of the punch holder is elevated ¼ inch above the rest of the plate for a space equal in width to that of the finished



Figs. 3 and 4. Combination Punch and Die used for Forming Picture Frame Backs.

product and ¼ inch less than its length. Against the edges of this elevation are placed the punch sections *N, N*, which are of tool steel, hardened and ground. When fastened in place the outside dimensions should equal those of the blank, Fig. 1, and fit between the cutting edges of the die. The inner corners should be slightly rounded with an oil stone to prevent cutting or scratching of the stock when turning over the edges of the blank. The space between the inside of the sections is equal to the size of the finished blank, Fig. 2. A tool steel plunger or plate *O* forms the knock-out device. This is not hardened but is nicely machined to fit between the punch sections. A tapped hole in the center receives the stud *P*, which projects through the shank of the punch holder and is held by the check nuts *Q*. Between the plate and the holder are placed the springs *R, R*, which are of sufficient length to produce a tension on the back nuts *Q* when the plate is flush with the face of the cutting sections of the punch. Two small punches *S, S*, are fitted into the punch holder opposite the small dies *T, T*, in Fig. 3. They are long enough to project ⅛ inch beyond the plunger plate when it is fully compressed inside of the holder and are fastened in the plate by the screw plug *U*. These serve the purpose of perforating the two small holes in the back of the holder. H. Robinson.

Montclair, N. J.

THE CUTTING POINT.

Editor Machinery:

When one stops to consider he cannot but be impressed with the vital bearing that the point of the cutting tool plays in the profit of any manufacturing concern. The amount of work that a machine will do is more often limited by this than by any weakness of the machine or its drives. The output of the heavily built lathes and planers, with their special drives, may be reduced to that of ordinary machines by the improper treatment of the cutting tool, either through ignorance or carelessness. Mr. Markham's recent articles in Machinery have pointed this out, but how many of us realize to what an extent it affects every-day work in practically every shop in America? Whether you are using any special steel or not, there is a right way to treat it for best results and a tool that is not in its best condition is reducing the output of a machine that may have cost several thousand dollars.

Perhaps we have been too economical to buy a good heating furnace and a few other appliances for the hardener, and we are "getting along" with the old forge where it is simply impossible to heat large tools uniformly or without forcing the fire so hard that the air blast strikes the steel. The tools cut, of course, but do we count the cost of stopping the machine more often to grind or change tools? Or the difference in the total day's work when the machine cannot be run up to its maximum capacity? But the loss is not confined to tools of this kind when the new air-hardening steels are doing so good work. If your milling machine cutters are not in their best possible condition the difference in the amount of work that can be done will go a long ways toward putting in proper facilities for hardening and tempering. "Standing up" under a heavier feed, or needing fewer grindings, means more in the cost of production than we are apt to realize. Taps, dies, forming cutters and other tools come under the same category with the added feature of being more apt to be cracked in hardening. The spoiling of a tool, that perhaps represents several days' labor, from lack of knowledge or facilities means not only the direct loss of the tool but often serious delay to the work for which it was intended. When I recall the milling cutter with numerous teeth missing from "fire cracks," as we called them, taps minus part of their cutting edges and dies that were sprung out of shape I wish that we had known how to handle steel years ago. "Fire cracks," by the way, used to be our scape-goat and if a tool showed these cracks all hands were usually exempt, sometimes including the hardener. I used to do something in the hardening line myself and do not recall many serious mishaps although without doubt the tools were worked far below

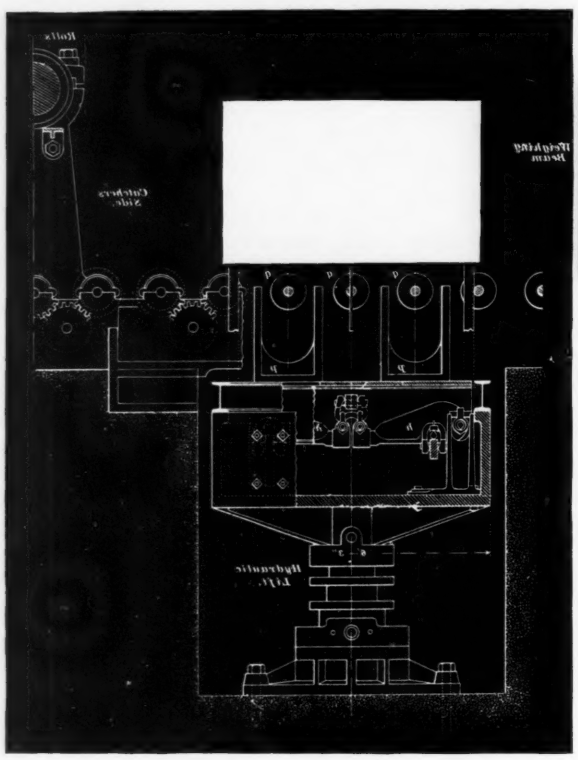
their best capacity. Many of the tools were hardened on an old portable forge, although they were too large for this to have been attempted, and if the cost sheets were accurately made out the amount of work which these tools did was probably way below normal. And so it all comes back to the first statement that the efficiency and economy of our up-to-date tools depend on the condition of the cutting point of the tools. I believe there is a larger return for the money invested to be had here than in any other place in the shop.

New York, N. Y. FRED H. COLVIN.

PLANS DRAWN QUICKLY.

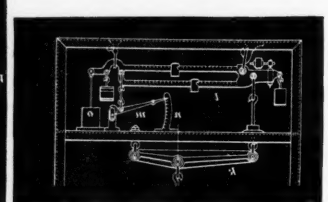
Editor MACHINERY:

In order to effect the sale of a large amount of their machinery to a foreign customer, an American firm was asked to submit plans at once with their "tender" showing the full construction of the machine, including certain changes asked for by the customer. These changes were slight and were



not in themselves difficult to make. The plans, however, were in the form of tracings, quite elaborate and in use every day. The firm did not wish to make any changes on the tracings, neither did they have sufficient time to make new ones. It was about decided to take off blueprints from the original tracings and make "stickers" showing the changes, which could then be pasted on over the original print. This is always a makeshift and in this case was strongly objected to, since the customer might possibly infer that the machines were manufactured in the same slipshod manner. In this emergency one of the draftsmen became inspired with an idea which prompted him to make the following offer: "If you will give me an order on a photo supply house for some paper, I will agree to make all the changes required and have the plans printed and ready to mail to-morrow morning." As no one had any better proposition, and as he seemed confident of his ability, a *carte blanche* requisition was given him. Although this was a hurry order he did not appear in any haste, but proceeded leisurely to make a small tracing showing the changes, then spent the rest of the afternoon lettering a very elaborate title stating that the machine was designed specially for "So and So," naming the intending purchasers. He went home to supper with the rest of the boys, and on his way back to the office in the evening he stopped in at the photo supply dealers and on the strength of his requisition obtained a package of bromide paper of the size of his drawings (the kind marked "thin, hard," is the best for this business). After dark—for this paper is very sensitive to the light—he loaded a printing frame as though to make a blue print, using the bromide paper in place of the blue. He put in the tracing *bottom side* up, so that the lines came in contact with the paper. After exposing the frame to an incandescent light for about 15 seconds he developed and fixed the print according to directions accompanying the paper, thereby securing a negative like the one shown in the illustration. As you will see, everything is reversed, dark for light, and left for right, so that the lettering, etc., reads backward, this latter feature being the result of turning the tracing over. After this negative was washed and dried, he cut out the portion which was to be changed, and inserted the print shown at the right, which he had made embodying the changes, covering the joint with black court plaster.

In this simple and inexpensive manner, with only a few hours' work and without defacing the original tracing, he secured a complete negative embodying the changes so neatly that the alterations would not be noticed. From this negative it was an easy matter to make the necessary number of prints on the bromide paper, the resulting copy showing black lines on a white ground, giving the effect of an original drawing even to the slight gloss of the ink lines. This feature is quite an advantage when the plans go to England, as in that country the appreciation of handwork amounts almost to worship.



Drawings on paper can be copied in the manner described, being careful to load the frame so that the ink lines will be in contact with the sensitive paper. Of course paper drawings require a longer exposure than tracings, a drawing on white paper like a patent office drawing requiring two or three minutes by an incandescent lamp, while a drawing on buff, "duplex," or detail paper could hardly be printed by artificial light as the yellow color retards the printing to that extent.

Velox paper can be used equally well, except that it is very much slower to print. This difficulty is largely offset by the fact that it can be handled with much less care as regards the light. W. H. SARGENT.

St. Johnsbury, Vt.

PUNCHES AND DIES USED IN MAKING RIM FOR LENSES.

Editor MACHINERY:

The accompanying drawings show three dies and punches that are used to produce the ring shown in Fig. 1 in three successive operations. This ring is used as a rim for holding lenses and the construction of the dies may be of interest to those who have occasion to make a set of tools for any similar article. The material from which these rims are made is "half-hard brass," as it is called. In Fig. 1, *A* shows the punching after the first operation, while Fig. 2 shows the punch and dies by which the operation is performed. The forming

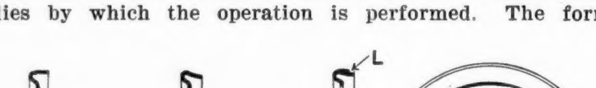
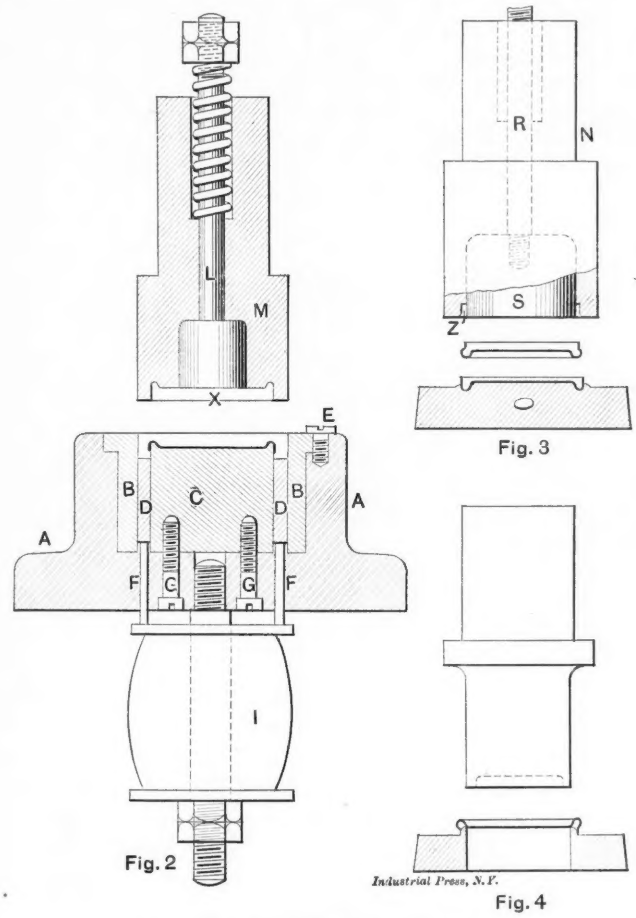


Fig. 1. The Successive Operations by which the Ring is Formed.

punch *C* was first turned to the outside diameter of the lens and a templet of soft wire, representing the cross section of the rim, assisted in obtaining the proper form of the face. The hardening of *C* was postponed until the last, as the two holes for the screws *G, G*, were not drilled until the die had been assembled. The punch *M* was then turned, leaving it a little larger than finished size, and while in the lathe the recess and the hole for the knock-out mechanism were drilled. By the use of the templet the recess *X* was turned out nearly

to size. The templet was then soldered across the face of *C* and with the help of a little red lead, to show up the high spots, this recess was readily finished correctly. To obtain the diameter of the cutting die and punch, *B* and *M*, the wire templet was unsoldered and straightened out. After the outside of *M* had been turned to this diameter it was taken to the gas furnace and hardened. As no grinding facilities were available, great care was taken to heat the punch slowly and evenly with the result that it came out of the bath as true as when it was taken from the lathe.

In making the blanking die *B* it was bored from the back so that the hole was about .004 inch smaller at the cutting edge than at the back. The die bed *A*, of cast iron, was bored out to receive this die and after it had been inserted three holes were drilled and tapped, half in the die and half in the bolster, as shown at *E*. In these were fitted three screws to keep the die in place. This die was hardened with the same care that was exercised in hardening the punch. The next step was to make the tool steel bushing *D*, which slides between the forming and the blanking dies. The parts of the die were then assembled and two holes for the screws *GG*



Punches and Dies for making Lens Rings.

were drilled and tapped from the back of the die bed into the forming punch *C*, which was then ready to be hardened. *FF* represent two of the steel pins which press against the bushing *D*, and *I* is a soft rubber bolster by which the pins are held up in place.

The die operates in the following manner: The blanking punch *M*, entering the die *B*, cuts out the blank to the proper diameter. As the punch travels downward it bends the blank over the forming die *C* and, coming to a stop, it forms the ring shown at *A*, Fig. 1. When the punch ascends, the bushing *D*, having compressed the rubber bolster, strips the blank off from the forming die *C* and the punch carries it upward until the knock-out strikes the knock-out arm in the press at the end of the upward stroke. As the press is tilted, the blank then drops clear of the die, into a box.

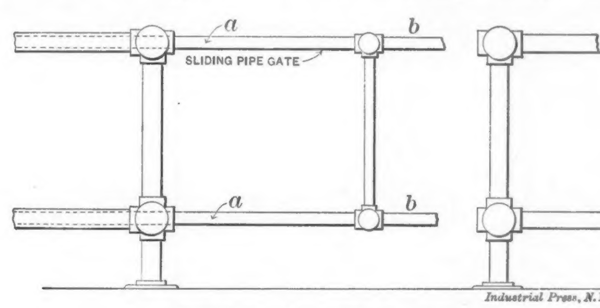
Fig. 3 shows the punch and die used for reducing the diameter of the punching, as shown at *B*, Fig. 1. The die *O* is turned out on its face to receive the blanks, one of which is shown in the position in which it is placed ready for the punching. In the punch, the recess *Z* is bored to the required diameter and the hole and recess for the knock-out and knock-out stem, *S* and *R*, are also bored at the same setting. The recess *Z* is beveled off slightly to locate the punching. The action of this punch is similar to that for performing the first operation. The punching is carried upward until the knock-out strips it from the punch and the tilted press allows it to drop into a box. Between the punch and die is shown one of the pieces as it is ejected from the punch. Fig. 4 shows the tools that are used for blanking out the bottom, leaving the work in the shape of a ring shown at *C*, Fig. 1. Before the bottom is blanked out, however, the ring is reduced considerably at its rim as at *L*. This is done in a monitor lathe, the punchings being mounted on a spring collet and an ordinary cut-off tool being used. The reduced part is afterward bezzeled over a lens. FRANK GREINER.

New York City.

SIMPLE SLIDING GATE FOR MACHINE SHOP.

Editor MACHINERY:

At the new shops of the American Turret Lathe Co., Warren, Pa., recently visited by the writer, a simple sliding gate for the gallery was observed which is made entirely of pipe and pipe fittings, and which utilizes the adjacent pipe railing for guides. As it appeared to serve its purpose fairly well, a



Shop Gate made of Pipe Fittings.

sketch is given herewith which makes the construction understood with little explanation. The gate is, of course, made of a size of pipe smaller than the adjacent pipe sections constituting the gallery railing so that the ends *a a* can slide freely within them. The ends *b b* also slide into the opposite pipe ends of the opening when the gate is closed.

F. EMERSON.

* * *

In a paper on radium and other radio-active substances read by William J. Hammer before an extra meeting of the American Institute of Electrical Engineers, April 17, some interesting facts regarding radium and selenium were discussed. It has been demonstrated by the Curies that radium at all times maintains a temperature of 1.5 degrees C. (2.7 degrees F.) above its surroundings. A half-pound of radium salt is estimated to evolve as much heat in one hour as the burning of one-third cubic foot of hydrogen gas, and the heat radiating from pure radium would melt more than its own weight of ice every hour. Mr. Hammer has recently received a notification from the Société Centrale that they will shortly put pure radium on the market at a cost of 30,000 francs per gramme or about $2,721,555.90 per pound. The enormous cost is due to the great difficulty of separating radium from the uranium residues from which it is separated, it being necessary to handle 5,000 tons of the residue to obtain 2.2 pounds of radium. In regard to selenium the author referred to an interesting and valuable application of selenium to regulating the light emitted by Pintsch gas buoys, which are anchored at the mouths of bays and rivers to mark the entrance, etc. Heretofore it has been necessary to let the gas burn night and day because of the impracticability of any ordinary apparatus designed to shut it off during the daylight hours. A selenium cell, which is highly sensitive to light in the matter of electrical conductivity, gives a practicable means for turning the gas on and off so that it is only consumed during darkness. In this way it will be possible to make the gas of a Pintsch buoy which now lasts only a month, last two or three times as long.

A GEARED VARIABLE SPEED MECHANISM.

FRED S. ENGLISH.

At the present time there seems to be, among machine tool and automobile designers, a tendency for a geared variable speed transmitter, capable of a wide range of speed coupled with an almost instantaneous change without stopping the machine. This has already been accomplished in various ways, several of which might be enumerated with their good points and faults, would space permit. The scheme which I am about to describe for accomplishing this is more elaborate and probably more expensive than any the writer has seen, but to offset this objection the method of operation is extremely simple; the operator simply pulls a rope and the machine automatically shifts one notch, with no shock, and locks itself in the new position. It can easily be arranged with a positive reverse and backing motion for an automobile.

The fundamental idea of the device consists in driving from a cone of gears to a sliding gear through a series of free running intermediates so placed that the faces next the sliding gear all come in line so that the gear is simply slid on the shaft without the necessity of moving on a swinging arm. Now, if when the machine is assembled the intermediate gears are arranged so that the teeth opposite the sliding gear all line up, they will always line up whenever the cone of gears comes into the same position again. In this position the sliding gear can be moved from one intermediate to the next by means of a cam, with no shock and no danger of breaking the teeth.

Free on a stud and meshing in the rack teeth *U* is a gear *X* and made integral with this gear on the top is a ratchet *Y*, while on the bottom is a plate *AQ* having a series of notches in its circumference and under this another ratchet *Y′* with its teeth pointing in the opposite direction from those in *Y*. Swinging on the same stud as the gear are the bell cranks *A J* and *A J′* carrying pawls *Z, Z′*. These pawls are normally held out of contact with the ratchets by means of a spring between *A G* and *A F*, the stop *A H* resting against *A I*, (this is not shown on pawl *Z′*;) either pawl is placed in action, when required, by pulling the rope *A E* or *A E′*, one rope moving the sliding gear in one direction and the other moving it in the other direction. Lever *A C*, swinging about a stud in *A O* carries the roll *A D*; this is held against the notched plate *A Q* by means of a spring *A B* and serves to lock the gear *X*, and consequently sliding gear *F*, in any position. Bell cranks *A J*, *A J′*, are operated with the cam *N* through the levers *A L*, *A L′*.

Gears *A*, *B*, etc., are keyed in such a position that the teeth in the intermediate *D*, *E*, etc., opposite gear *F* are all in line so that *F* may be slid easily from *D* to *E‴*. Place the gear *F* half way between any two intermediates and the gear *X* in such a position that the roll *A D* comes exactly half way between the two notches corresponding to the position of *F*. Set the cam *N* so that the lever *A L* has moved to mid position. Pull the pawl *Z* into action and turn the shaft *M* around until the still run of cam is reached and gear *F* will have moved fully into gear with the intermediate at the right.

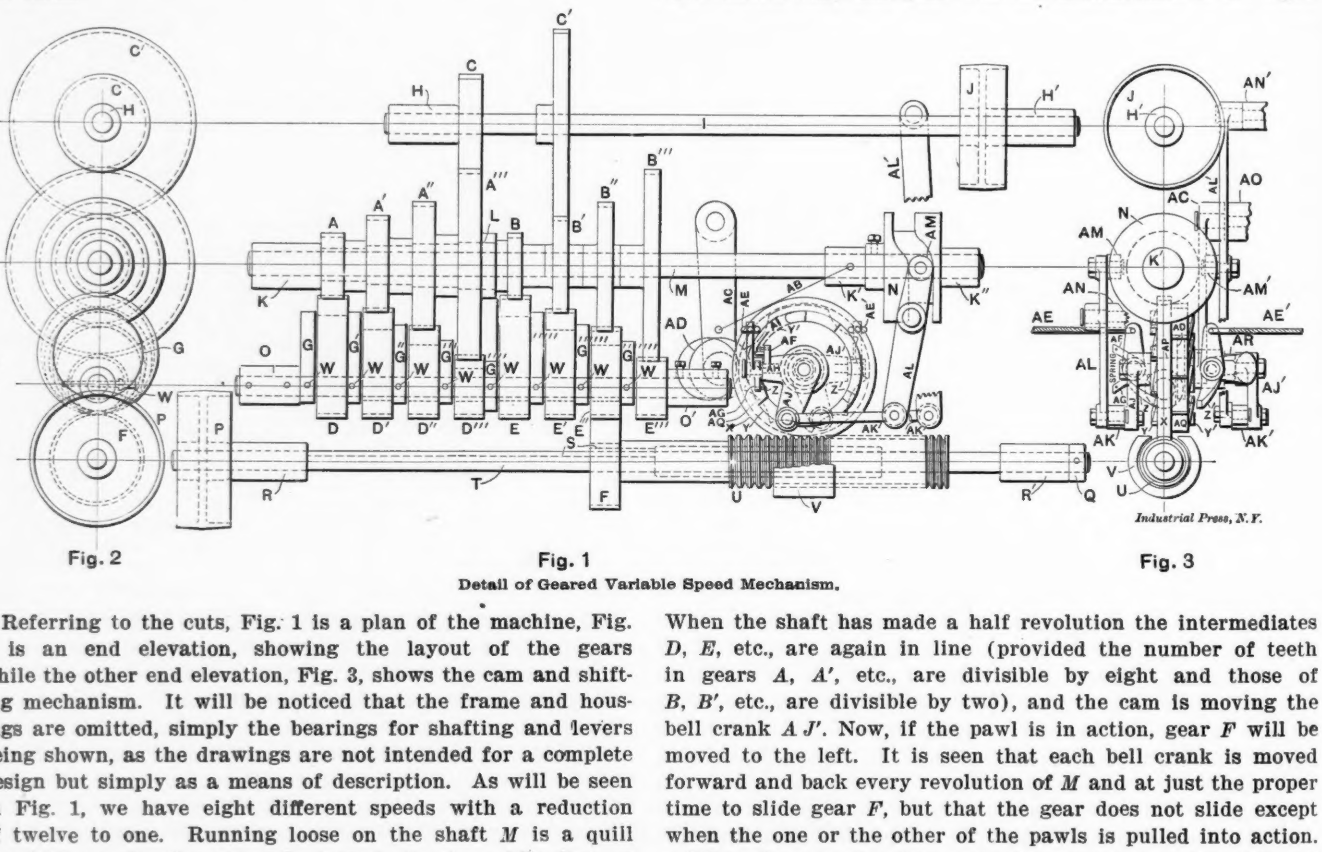


Fig. 2 Fig. 1 Fig. 3

Detail of Geared Variable Speed Mechanism.

Referring to the cuts, Fig. 1 is a plan of the machine, Fig. 2 is an end elevation, showing the layout of the gears while the other end elevation, Fig. 3, shows the cam and shifting mechanism. It will be noticed that the frame and housings are omitted, simply the bearings for shafting and levers being shown, as the drawings are not intended for a complete design but simply as a means of description. As will be seen in Fig. 1, we have eight different speeds with a reduction of twelve to one. Running loose on the shaft *M* is a quill *L*, which carries the cone of gears *A*, *A′*, etc., while fast on the same shaft is another cone of gears *B*, *B′*, etc. These gears and shaft are driven from the main driving shaft *I* through the gears *C*, *C′*. This scheme of driving *A*, *B*., etc., from shaft *I* instead of putting the pulley *J* directly on shaft *M* is to keep gears *B*, *B′*, etc., from becoming excessively large, and could easily be omitted if the range of speeds was not over six or eight to one. Fast in bearings *O*, *O′*, is a shaft carrying eccentrics *G*, *G′*, etc., collars of which are pinned to the shaft with the taper pins *W*, *W*, and may be braced from the frame if thought necessary. Running free on the collars are the intermediate gears *D*, *E*, etc. Sliding on a feather *S*, on shaft *T*, is a quill having rack teeth *U* cut in its circumference, and carrying gear *F*. The ends of the teeth on gears *D*, *E*, *F*, etc., are tapered off (see Fig. 5) to give an easy entrance for the sliding gear. Shaft *T* carries the pulley *P* which drives the mechanism in question.

When the shaft has made a half revolution the intermediates *D*, *E*, etc., are again in line (provided the number of teeth in gears *A*, *A′*, etc., are divisible by eight and those of *B*, *B′*, etc., are divisible by two), and the cam is moving the bell crank *A J′*. Now, if the pawl is in action, gear *F* will be moved to the left. It is seen that each bell crank is moved forward and back every revolution of *M* and at just the proper time to slide gear *F*, but that the gear does not slide except when the one or the other of the pawls is pulled into action.

When the gear has been moved to one end or the other of its throw it cannot be moved out of gear, no matter how much the rope is pulled, if the remaining teeth are cut off the ratchet. By continuing to pull one cord the speed can be changed from one extreme to the other during seven revolutions of shaft *M*, or during about six revolutions of shaft *T*, depending on the ratio of the gears.

Fig. 4 shows the cam developed, and Fig. 5 shows various positions of gears *E*,*″ E*,*‴* and *F* (looking directly down on the tops of the teeth), while the cam moves from *B D* to *B C*; it is seen that the gear *F* begins to move some time before *E″* and *E‴* are in line and that they are not exactly in line until *F* is half way across. The first position is with the cam roll at *B D* while *E‴* is one-quarter of a tooth behind *E″* and *F* just passing by the ends of tooth *E″*, in the second position *E″* has moved one-quarter of a tooth and *E‴* three-eighths of a tooth, making *E‴* only one-eighth

of a tooth behind E''; in the third position E'' has moved one-half of a tooth and E''' three-quarters of a tooth making E'' and E''' exactly in line while F is just half way across; in the fifth position E'' has moved one tooth and E''' one and one-half teeth, making E''' one-quarter of a tooth ahead of E'', while F is just leaving E''' and being driven entirely by E''.

An indicator moved by gear F should be placed on the outside of the frame (in case the gears are inclosed) to show the operator the exact position of gears. A better action could be obtained to the pawl by making the ratchet teeth parallel to the teeth of gear X. They were made as shown for constructive reasons, it being easier to cut the teeth of ratchet in this

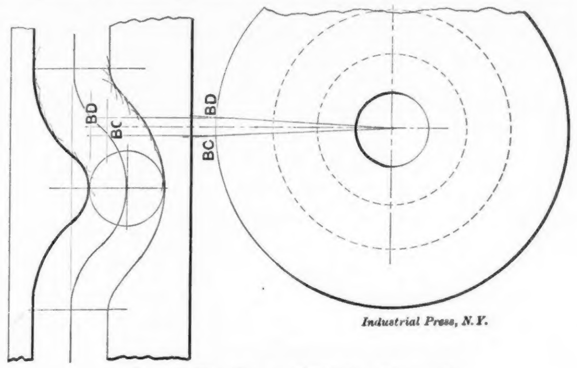


Fig. 4. The Cam and its Development.

position, and it also requires a less number of sheaves to bring the rope into a convenient position. The ropes should be provided with balls at the bottom for pulling easily and also with a guard to prevent them from swinging in an arc with the bell cranks. V is a bearing for the quill rack that keeps it from springing out of mesh and makes it possible to have shaft T lighter than would otherwise be required.

For an engine lathe the pulley J should be replaced by the usual reverse pulleys and clutch or with tight and loose

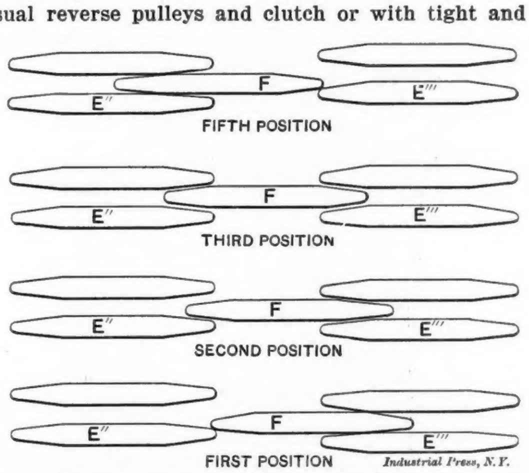


Fig. 5. Position of Gear Teeth during Portion of the Cam Throw.

pulleys as required. Suppose it is required to make a positive reverse and backing motion, say for an automobile. Turn the cone of gears A, A', etc., end for end and drive them in a reverse direction by means of an intermediate between C and A'''; spread intermediates at D''' and E far enough apart to put another gear similar to them between them and driven from either one by means of a spring key, which is thrown from E to D''' by motion of the gear F. To reverse, pull the rope moving F off from E onto the intermediate between E and D'''. By means of this motion the spring key can be moved from E to D''' and when the gears come into register the spring gear will drop into place reversing the gear F; pull the rope again and F moves on to D''' and so on to the fastest backing motion. The gearing can be so arranged as to make E and D''' revolve very slowly, thus making but little strain in reversing.

* * *

The craze for high speed has resulted in some racing automobiles equipped with engines of extraordinary power. At a recent tournament at Nice, France, a machine was entered having a wheel base 9 feet 9 inches long and a four-cylinder gas engine of 110 horse power.

ITEMS OF MECHANICAL INTEREST.

MILLING CIRCULAR T-SLOTS–COMBINED DRILL DRIFT AND HAMMER–NEW TYPE OF MILLING MACHINE–STEAM STEERING GEAR–MAMMOTH TRACTION ENGINE.

The band saw which is now generally used in all up-to-date woodworking mills, probably puts tempered steel to the severest possible test. It runs like a belt over wheels of moderate diameter, under considerable tension and at high speed. Every time a section of the saw makes a complete circuit it is bent back and forth twice, and this takes place many times a minute, day after day for astonishingly long periods before the saw breaks. And then the practice is to mend the break by sweating together with silver solder and scarfing down the ends until the joint is of the same thickness as the body of the saw. How long a band saw can be run before it begins to break so often as to make it unprofitable to continue repairing it, we do not know. A comparatively recent innovation in band saw machinery, which puts the steel under still further duress, a combination of bending and twisting stresses—is a band cut-off saw. In this machine the saw is twisted one-fourth way round by guides just after leaving the wheels so as to present the teeth of the saw in a plane at right angles to the log.

The operation of electric motors in a dust-laden atmosphere, especially that of a cement-grinding mill, is a problem that does not appear to be successfully solved by the use of the so-called "dust-proof" motors. A scheme tried in the Edison cement mills by which ordinary motors can be successfully used, consists of surrounding the motor with a light frame carrying a covering of porous textile material like gunny cloth, which acts as a dust sieve, but permits the air to pass through. To secure the necessary circulation of air to prevent heating of the motor, the air is drawn through the cloth covering and discharged at an opening by a small electric motor fan. The area of the casing is, of course, so proportioned that sufficient air is readily drawn through by the inductive action of a comparatively small fan, which is located within the casing and discharges through an opening in the side. To give a comparative idea of the size of the casing required, it may be mentioned that a five-horse power motor was incased in a frame four feet wide, four feet long and six feet high. This was covered with two thicknesses of cloth spaced two inches apart.

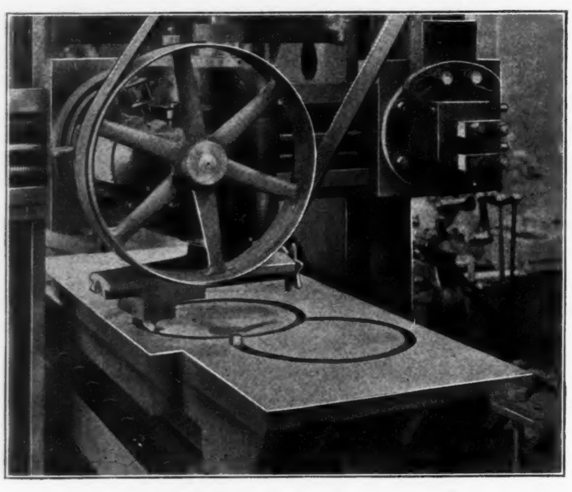
Mr. W. H. Booth, the well-known English writer on technical subjects, in a recent letter to the *Mechanical Engineer* discusses the errors that develop in limit gages of their (English) manufacture, and suggests the cause. He says that it does not appear possible to mechanically grind a gage to a guaranteed accuracy of 0.0001 inch, and consequently it is necessary to finish them by hand. In the hand-finishing process errors of parallelism are usually corrected by gentle pening on the sides or edges, thus putting the surface under tensional and compressive stresses. When a gage treated in this manner goes into the workshop, it maintains its accuracy until the varnish or japan on the body of the gage has worn away under the influence of the grimy, gritty hands of the workmen. The abrasion of the hand then soon wears away the surface particles, which at once permits a readjustment of the shape of the gage as the stresses are relieved. The result is, of course, an inaccurate gage with no apparent reason for such a condition. Mr. Booth then infers that adjustable gages of the type used by the Newall Company, are the best in the long run since the material is annealed and free from stress. This system of limit gages is considered less cumbersome and expensive than the solid type, and more accurate. The best makers of American gages grind them as closely as possible and then finish by lapping, no hammering or pening being allowed.

It so rarely happens that a steam boiler fails when subjected to the usual hydrostatic test by the builders, that the rupture of a large Scotch boiler under test at the Polson Iron Works, Toronto, Canada, is of considerable general interest,

especially when the physical properties of the steel plates revealed by the accident, are known. The shell plates were of steel, having a tensile strength of 60,000 pounds per square inch, and were 1 1-32 inches thick. At the time of the test two pressure gages were attached to the boiler and both indicated a pressure of 270 pounds when without warning the shell cracked in the solid metal, from one end to the other. Examination of the plates showed them to be very brittle, and when attempts were made to straighten them under a hydraulic press, they broke cleanly like glass. A number of fine cracks were discovered in the plates about 3-16 inches deep that had been produced by rolling them into shape for the shell. The incident demonstrates anew that eternal vigilance is the price of safety in the construction of steam boilers, especially in the material used. Who knows how many mysterious boiler explosions have been caused by defective material rather than the carelessness of firemen and engineers?

MILLING CIRCULAR T-SLOTS WITH PLANER ATTACHMENTS.

The half-tone herewith shows a method of cutting circular T-slots, that is employed at the shops of the Adams Co., at Dubuque. The castings, in which the slots are cut are quite large, weighing about 1,000 pounds, so that any method of machining that will save handling is of decided advantage. The plate is set on the platen of an ordinary planer and the top planed off in the regular way, using a tool in the planer head. The T-slots are then bored out by using the traverse head in connection with a Farwell milling attach-

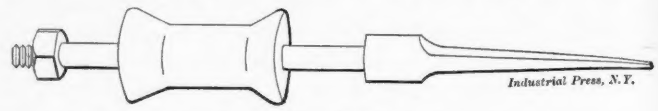


Planing Plate and Milling T-Slots at one Operation.

ment. The tools for this are placed in the sliding portion of the traversing head and are fed radially by the star at the other end. The vertical feed is obtained by lowering the cross rail. There will be no trouble in giving the miller an accurate vertical feed, by raising and lowering the rail, if care is taken not to loosen it too much from the housings. The rail should be just tight enough to prevent it from falling by its own weight which will allow the screws, instead of gravity, to impart the feed. As soon as one of the slots has been bored, the platen of the table is run forward and the milling head set across the cross rail until the work is brought into position for the second hole which is then milled exactly as the first. The entire work on the piece is thus accomplished with a single setting.

A COMBINED DRILL DRIFT AND HAMMER.

Although a drift for removing drills from the drill socket is usually to be found chained to the drill press, so as to be always handy, any one who has had much experience in drilling has often realized that but one-half of the purpose is accomplished, for as soon as the drift is inserted in the hole the machinist must hunt about for a hammer with which to drive it. The hunting part of the operation generally occupies more time than the actual removal of the drill so it has occurred to some one to combine with the drift a device for pounding the same so that the use of the hammer will be unnecessary. This device, as shown in the cut, consists of a regular drill drift at the end of which is a cylindrical shank. Sliding on this shank is a heavy iron spool which is retained by a nut on the outer end. When a drill is to be removed the drift is inserted in the usual way, the spool pulled back on the shank and then pushed briskly



Combined Drill Drift and Hammer.

forward against the head of the drift, thereby producing a sharp blow which drives the drill from its socket. In the end of the shank, where it projects from the nut, there is a drilled hole by which the drift can be chained to any convenient point on the drill press. This drift is manufactured by the Maria Stein Machine Works, Maria Stein, Ohio.

AN INTERESTING MILLING MACHINE.

In the May number of MACHINERY there was published a description of a grinding machine employing the sun-and-planet motion by which the grinding spindle is made to describe a circle as it grinds the interior of a hole. This style of machine is employed in grinding holes in work that is too large or not suitably shaped to allow it to be rotated. The same principle has been applied by Mr. Eric Johnson, of the Seattle Machine Works, to the milling machine which is illustrated by the accompanying photograph and drawing. This machine, as originally designed, was intended for milling circular recesses in the rims of a variety of circular saws but it is equally applicable to all kinds of milling where it is necessary for the work to remain stationary while the cutter describes the circle being cut.

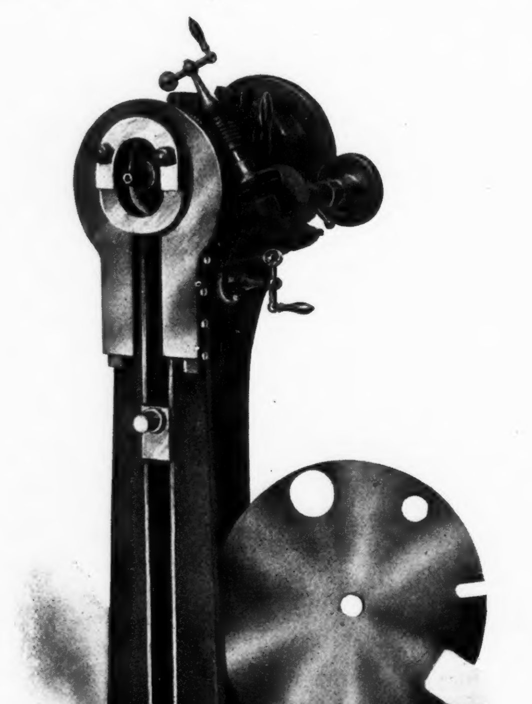


Fig. 1. A New Type of Milling Machine.

At the foot of the machine shown in the photograph, will be seen one of the saws that has been milled with several holes and slots showing the class of work of which the machine is capable. The saw to be milled is mounted on the pin *H* which has a vertical adjustment, by means of the handwheel *I* and the miter gears *J*, to accommodate saws of any diameter within the capacity of the machine. For general use this pin would be replaced by an elevating table on which the work would be held. The milling cutter *M* is carried on a spindle *D* which runs in an eccentric hole in

the sleeve *E*. This sleeve, in turn is carried in another eccentric sleeve *C* which is free to rotate in the head of the milling machine. Upon the back of the sleeve *E* is a worm wheel which is operated by the worm *F*, mounted on the end of the sleeve *C*. Turning this worm, by means of a wrench applied to the flats on the end of the worm shaft, will therefore cause the inner sleeve to turn within the outer, and as the eccentricity of the shaft in the inner sleeve is equal to that of the inner sleeve in the outer it will be seen that it is possible to bring the shaft concentric with the outer sleeve or to off-set it so that during a revolution of the outer sleeve it will travel in a circle whose diameter is equal to the combined eccentricity of the two sleeves. A pointer *S* upon the sleeve *E* indicates the amount of eccentricity as shown by the graduations on the sleeve *C*.

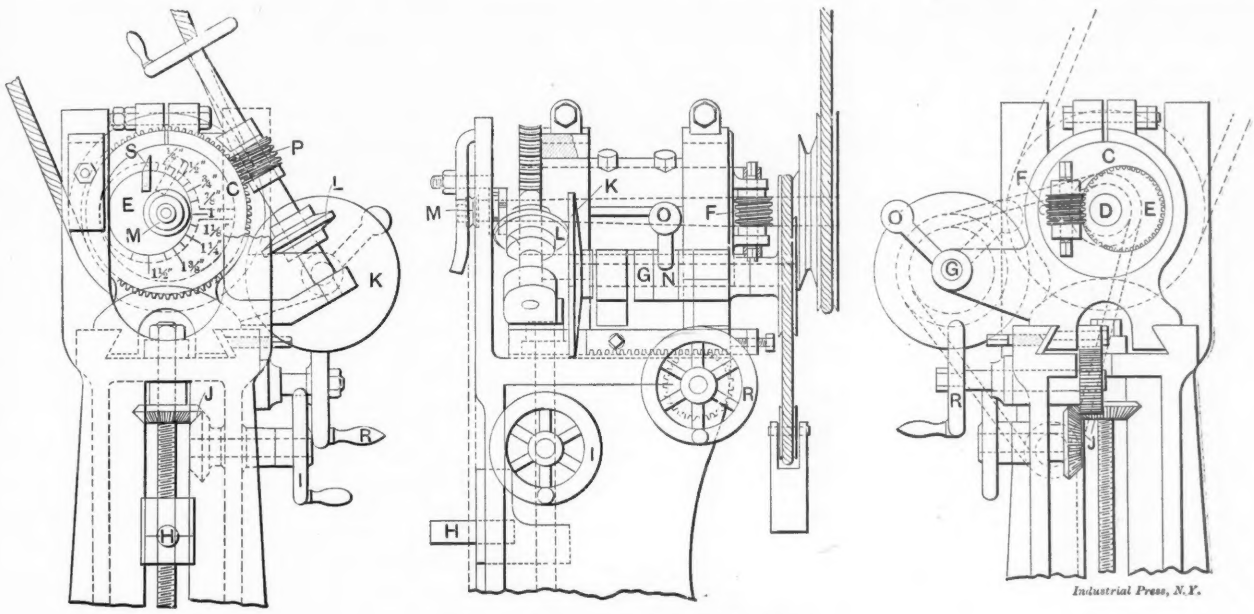


Fig. 2. Details of Special Milling Machine.

The cutter itself is driven by a rope running over a grooved pulley which is keyed directly to the spindle. From another sheave on this pulley a rope passes over a sheave on the end of the shaft *G*, while a counterweight provides for the difference in distances between the spindle and the shaft *G*, due to the spindle moving about a center while the shaft *G* remains stationary. Upon the forward end of this shaft is the friction disk *K* which, by means of a cam and lever *N* and *O* may be forced into or thrown out of engagement with the friction wheel *L*. The shaft on which this friction wheel is mounted carries a worm *P* which meshes with a worm wheel on the front end of the sleeve *C* and causes it to revolve in the head of the machine, thus causing the spindle to describe a circle of the required diameter. The head itself is dovetailed to the column of the machine and may be fed forward or back by means of a rack and pinion operated by the hand wheel *R*.

STEAM STEERING GEAR FOR U. S. TORPEDO BOATS.

The accompanying cuts show a simple type of steering engines and gear used on some of the government torpedo boats, the particular engines illustrated being used on a boat built at the yards of the Fore River Engine Co., Quincy, Mass. At the center of the crank shaft of the engines is a worm which drives the rack, Fig. 1, through a worm wheel and pinion. This rack gives motion to the rudder. There are two engines operating on the same shaft and between their cylinders is the controlling valve, which is moved up or down to start the engines in one direction or the other. The valve is moved by a lever actuated by a nut on a threaded section of the tall vertical shaft at the front of the engines. The problem is to have this valve so operated that when the steering wheel is turned in one direction a definite amount, the rudder will be turned by the engines in a corresponding direction, and also a definite amount, depending on the distance the steering wheel is moved. In any steam steering gear the interesting portion of the mechanism is that part connecting or regulating the relative motions of the steering wheel, the rudder and the engines. When the steering wheel is moved, the engines must start, which in turn moves the rudder; and when the rudder has reached the desired point its motion must act upon the engine valve to stop the motion of the engines.

The essential features of this mechanism of the engines under consideration are indicated in the diagram in Fig. 2, and the most important parts of this diagram are the steering wheel *A*, the vertical shaft *B*, the nut *C* on the threaded portion at the lower end of the shaft, and the connections; first, between this nut and the engine valve, by means of the lever *D*; and second the rack *R* by means of the gears *E* and *F*.

When the steering wheel is moved, the shaft *B* turns, and as the nut *C* is kept from rotating by its geared connection

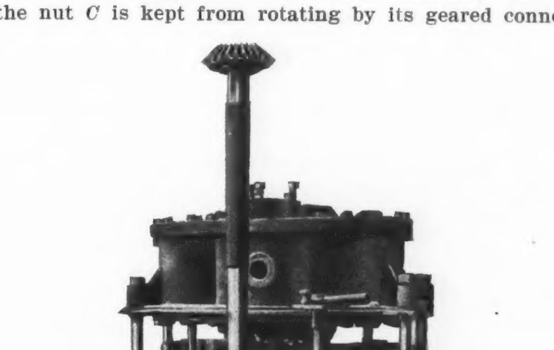


Fig. 1. Steam Steering Gear.

with the rack *R*, it screws up or down on the shaft *B* according to the direction in which the latter rotates. This vertical movement of the nut *C* actuates the engine valve by means of lever *D*, whereupon the engine starts and slides rack *R* one way or the other and so moves the rudder. As soon as the rack moves, nut *C* begins to turn, being driven through,

gears F and E, and screws back to its central position, closing the engine valve. This of course stops the engine, and the distance that the rudder has moved is gaged by the distance nut C has been raised or lowered by the motion of the steering wheel A. It will be seen that the function of the nut C

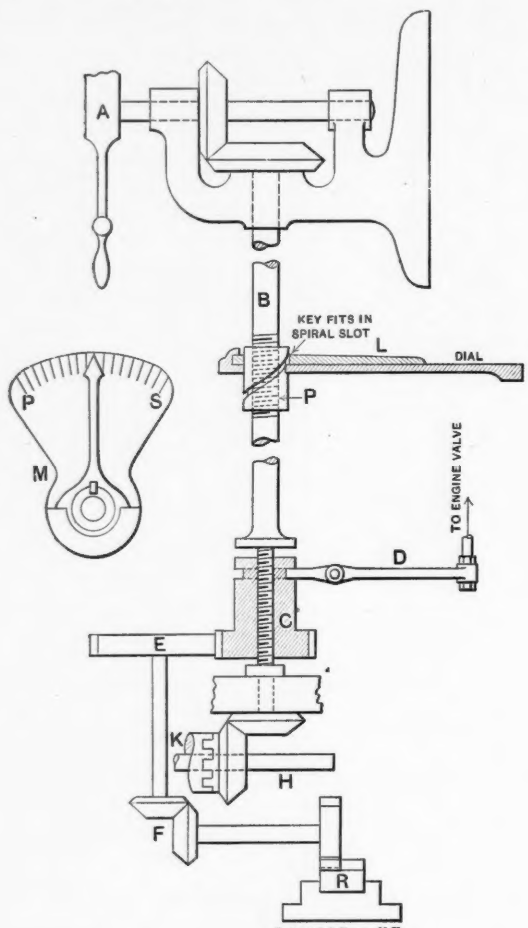


Fig. 2. Diagram of Steam Steering Gear.

is the same as that of a floating lever, the rising or lowering of the nut being in effect the same as the tilting action of a lever.

The steering wheel A is located in the pilot house of the vessel and connection may also be had with a wheel on the bridge by means of gears H at the lower end of shaft B, this connection being thrown in or out by the clutch K.

With any steering arrangement it is necessary to have some way of knowing what the position of the rudder is at any time, and this is here accomplished by the pointer or indicator L, also shown in plan at M. On a threaded section at the upper end of shaft B is a nut P, on the outside of which is cut a spiral groove. The pointer fits over the outside of the nut, and a key is fitted to the spiral groove and also to a spline in the pointer. The nut cannot turn but moves up and down with the motion of the shaft and the spiral groove causes the pointer to indicate the position of the mechanism and hence the position of the rudder, to port or starboard.

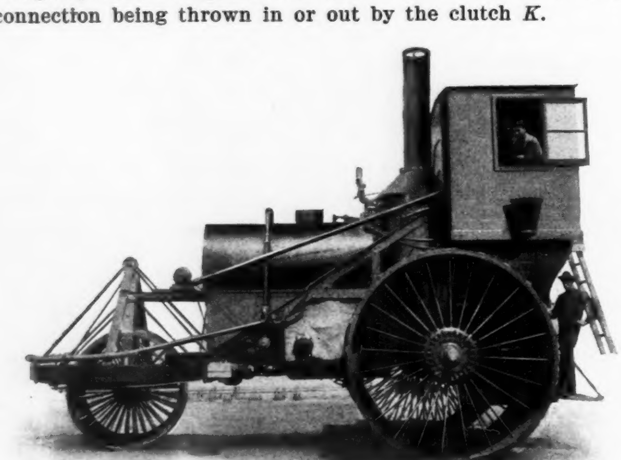
MAMMOTH TRACTION ENGINE.

The development of the traction engine for hauling purposes, has reached an advanced state in the far West, especially in California where it is largely used for drawing trains of wagons in place of mule teams. The relative cost of freighting by traction engines and mule teams, is said to be about as 1 to 2. It is not unusual for the larger traction engines of, say 50 H. P. to haul loads of 20 to 25 tons at the rate of 3 to 4 miles per hour, and on grades of 12 to 15 per cent. they will handle from 75 to 80 per cent. of the above loads. One striking feature of these western traction engines is their very large and broad driving wheels, 7 feet diameter and 2 feet width of tire being common. The steam pressure is high, being from 125 to 150 pounds.

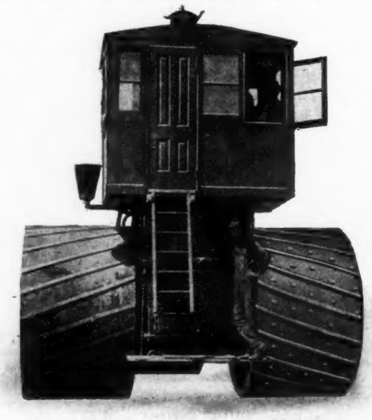
The accompanying illustrations show side and rear views of a heavy high-powered traction engine, being a 110 H. P. three-wheeled engine built by the Best Manufacturing Company for the Middle River Farming Company. The steering wheel is 5 feet diameter and the width of the tire is 14 inches. The rear driving wheels are 8 feet diameter and the tire widths 26 inches. The total width of the engine is 9 feet 7 inches and the weight is 31,000 pounds. The hauling capacity is equal to that of 50 horses which means that it can draw loads of 50 to 65 tons exclusive of the weight of the wagons. The boiler is a combination vertical and horizontal and can safely carry a pressure of 150 pounds. The obvious advantage of a vertical boiler is that when working on grades, there is no danger of the crown sheet being uncovered if the normal water level is maintained.

It will be noticed that the cab is tightly constructed and that there is a small fan blower in front of the water tank with its discharge pipe connected to the cab. This construction was necessary for the engine shown, as it was made for plowing on an island having a very soft, light, ashy soil. The dust rises in such great clouds when the engine is pulling the plows that it is impossible for the engineer to breathe, let alone seeing ahead from his position on the engine. Hence it was necessary to overcome this difficulty by building the cab tight like a house, with openings near the roof so that when the dust penetrates it the blower can be set in operation to furnish fresh air and to blow the dust out.

Fuel oil is used for this engine, the oil tank showing in the rear view just above the firebox. When using coal or wood a small supply is stored in the space occupied by the oil tank, and a larger supply carried on a tender. While the traction engine is scarcely a thing of beauty, it has proved to be a most valuable and indispensable factor in conducting large enterprises of the West, especially in regions remote from the railways.



110 H. P. Traction Engine.



Traction Engine (Rear).

* * *

The nickel-steel alloy having the least coefficient of expansion (about one-thirteenth that of wrought iron) to which we have referred several times, is patented. In England it is sold under the trade name of "invar."

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

26.—Will you kindly tell me what features the Engineering Edition of MACHINERY has, not included in the shop edition, that would be of benefit to the ordinary machinist? 2.—Will you or some of your readers give details of a boring attachment to go on the head of a planer? If this is to be driven by rope drive I would like details of that also. 3.—Also details of attachments for a lathe for internal and external grinding of reamers, cutters, etc.

A.—The Engineering Edition contains a summary or condensed report of the leading articles upon mechanical subjects that have appeared in other publications, thus giving a reader of MACHINERY information upon important topics discussed in various journals which he probably would not subscribe for or even see at all. To show how much valuable material appears in this department we will mention the subjects of a few articles reviewed in the last number of the paper. Among these were: The application of reversing motors to planers; the construction of concrete chimneys; description of the new Curtis steam turbine, which is now manufactured by the General Electric Company; description of a new type of German boiler in which a water tube boiler is combined with an internally-fired boiler; description of an English grinding machine operating on a new principle; reports of tests on the Banki motor—a German gasoline motor which operates on a new principle enabling very high economy to be secured; report on the performance of water-tube boilers in the government boat *Marietta*, this being the first thorough trial of marine water-tube boilers in which unbiased results could be made public; and finally the results of tests by Geo. H. Barrus, the consulting engineer, to show whether reheating receivers in compound engines are really of value—a disputed question among engine builders. All of these subjects are live topics, and important ones, and any machinist who is trying to keep in touch with things will be interested in them. In addition to this review the Engineering Edition contains several articles not found in the shop edition, some upon machine design —good to file away for reference—and some of a descriptive nature telling about machinery of general character aside from machine shop tools—steam engines, for example. What is considered by many of the greatest value, however, is the monthly data sheet given with the Engineering Edition, in which are tables, diagrams and condensed data relating to shop work and machine design. 2.—We will refer this question to our readers and also suggest that you write the Adams Co., Dubuque, Ia., who manufacture a milling attachment for planers. 3.—If you will consult our advertising columns under the head of manufacturers of "center grinders" you will find several attachments mentioned suitable for cutter grinding in the lathe. You can probably purchase these cheaper than you could make an attachment yourself.

27.—S. T. E.—Will you kindly explain the term horse power as applied to a steam boiler? Does it mean the same as when applied to an engine, and how is it determined?

A.—The term horse power as applied to an engine represents the capacity of the engine to perform a given number of foot-pounds of work, 33,000 foot-pounds per minute being taken as the standard horse power. This is determined by the formula:

$$H.P. = P \times L \times A \times N \div 33{,}000$$

in which

P = mean effective pressure, in pounds per square inch, acting on the piston.

L = length of stroke in feet.

A = area of piston in square inches.

N = number of strokes per minute = twice the number of revolutions per minute.

In a boiler the work is that of converting water into steam and cannot, therefore, be expressed in foot-pounds of available energy, so the standard of measurement usually adopted is the capacity of the boiler to evaporate a number of pounds of water of a temperature of 100 degrees F. into steam at a pressure of 70 pounds above that of the atmosphere. The evaporation of 30 pounds per hour under these conditions is called a boiler horse power as it is considered that this is the average requirement per indicated horse power of the engine. The horse power of a boiler depends directly upon the heating surface, but can be made to vary over a wide range by variations in the draft or in the method of firing. In designing a boiler it is generally customary to allow 12 square feet of heating surface per horse power, but this amount varies considerably with different builders. A very good rule for finding the approximate horse power of a tubular or water tube boiler is:

$$H.P. = N \times L \div 50.$$

in which

N = number of tubes.

L = Length of tubes in feet.

28.—O. H.—In making the pattern for a sprocket wheel, I have made use of the formulas given in Brown & Sharpe's catalogue for determining the outside, bottom and pitch diameters. These are, of course, correct, but I would like to inquire if some one has not a simpler method or formulas by which these dimensions can be determined.

A.—The formulas above referred to are the simplest that we know for determining the diameters for making sprocket wheels. If any of our readers can contribute any others or describe a graphic method for obtaining the same results, we should be pleased to receive the information.

29.—H. T.—How can I estimate the H. P. of a steam turbine, or figure out the indicated horse power. 2.—Are there any books on steam turbines showing different designs and data regarding the relative economy of turbines and reciprocating engines?

A.—The horse power of a steam turbine can be determined only by using a prony brake to measure the power; or, if the turbine is direct-connected to a generator, as is usually the case, by reading the ammeter and voltmeter on the switchboard. There can be no such thing as the "indicated power" of a turbine. The term applies to the power of a motor as determined by the steam engine indicator. An indicator cannot be applied to a steam turbine. The object of an indicator is to trace a line which shall show the pressure within the cylinder at every point in the stroke of an engine. In a turbine, of course, there is no cylinder and no means of determining what corresponds to the indicated horse power. 2.—We will refer you to "The Steam Turbine," by R. M. Neilson, and published by Longmans, Green & Co.; price $2.50.

* * *

A recent call at the Lehigh Valley R. R. shops at Easton, Pa., revealed some interesting locomotive tire turning work, which is, we think, far ahead of what is being accomplished in most railroad shops that are attempting increased product in this line. Locomotive driver tires are turned in a 90-inch Pond lathe at a cutting speed of 20 feet per minute, using tools made of Novo and Midvale steels. At the time of our visit one tool rest carried a Novo tool and the other was one made of Midvale steel. The difference in the work and durability of the two tools, is said to be practically inappreciable. A pair of 56-inch tires are turned complete in about three and one-half hours, or three pairs in something more than a day's work. A recent record showing rapid work, is the turning of the tires of a six-wheel-connected engine that went onto the drop-pit at one o'clock in the afternoon. The wheels were dropped and the tires turned, two new wedges put in and some other minor repairs made. The engine was ready to go out the next day at noon. Of course the wheel lathe ran all night, but the tires were turned the next morning at six o'clock.

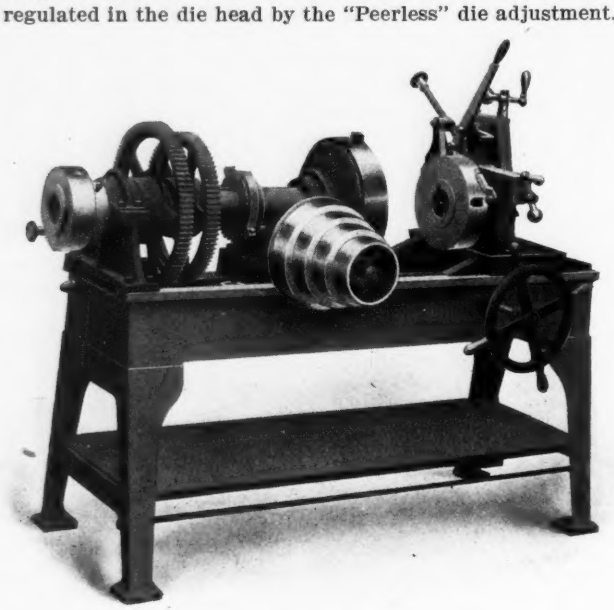
Tires were being bored on a Niles boring mill working at a cutting speed of about 32 feet per minute, roughing cut, and 50 feet finishing cut. They have run finishing cuts as high as 80 feet per minute. This is very high speed when the hardness of locomotive tires is considered. The ordinary roughing cut is ¼ inch and 3-16 inch feed. The three sizes, 56-inch, 62-inch and 70-inch tires are all bored in the same time, or 1 hour 20 minutes, no change of the belt on the cone pulley being made for the three sizes of tires.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

PIPE CUTTING-OFF AND THREADING MACHINE.

The half-tone presented herewith illustrates the "Peerless" special improved pipe machine, for cutting off and threading pipe, that has recently been placed on the market by the Bignall & Keeler Mfg. Co., Edwardsville, Ill. This machine combines simplicity of design with good proportion and accurate fitting of its parts which are so designed as to occupy a minimum amount of floor space. This machine, as regularly constructed, is driven from a cone placed parallel with the spindle, but when it is desired to secure a minimum amount of floor space occupied the cone may be mounted, as shown in the illustration, at right angles to the spindle. The capacity of this machine is from 1/4-inch to 2-inch pipe inclusive, and it is furnished with a complete set of dies, eight in all, for cutting each size of pipe within this range. Each set of dies consists of four chasers which are regulated in the die head by the "Peerless" die adjustment.



"Peerless" Threading and Cutting-off Machine.

The pipe to be threaded is securely gripped by a universal chuck in the front and held parallel by a scroll chuck on the rear. As both chucks are self-centering, accuracy and quickness in chucking is secured. The machine is furnished with an automatic oil feed arrangement whereby the oil is supplied to the dies and cutting-off tools and then returned to the bed of the machine. Cut gears are used throughout thereby insuring easy and noiseless running that cannot be obtained where cast gears are employed.

TEN-SPINDLE TURRET DRILL.

The A. E. Quint Co., Hartford, Conn., have just added to their line of turret drills the ten-spindle drill illustrated herewith. This machine is designed for light jig drilling where it is desirable to use several sizes of drills upon the work without removing it from the jig. The drill is so constructed that the feed of the work to the tool, the indexing of the turret head and the change of speed are all performed by the use of foot levers, leaving the operator's hands free to handle the jig or the work. Only the spindle pointing down to the center of the table rotates, and as all spindles, when indexed, point to same center the pressure of tool at work is at all times in center of table. Any spindle may be thrown into or out of action without stopping drill by means of the center foot lever which will release the turret locking pin. When the turret head is revolved to the spindle wanted the pin locks the head before the spindle rotates.

The two speed changing device consists of two friction pulleys on countershaft fastened to back side of the drill with a friction clutch between them, the clutch being held in contact with one of the pulleys by means of a weight, shown on end of foot lever. When necessary to change the speed of drill the foot is pressed on lever; this raises the weight and moves the clutch from one pulley to the other, then the flat spring on front side of base springs over top of lever and holds the clutch in contact with pulley. When the size of tools used demands more than two speeds, an overhead two

Ten-spindle Turret Drill.

speed countershaft may be used. Belted to countershaft on drill this will give four drilling speeds. The table is 14 inches by 20 inches; the distance from face of column to center of spindle 8 1/4 inches, while the greatest distance from the table to the spindle is 20 inches.

THE "HERO" EMERY GRINDER WITH DRILL GRINDING ATTACHMENT.

Figs. 1 and 2 illustrate a very convenient little emery grinder that has lately been placed on the market by the Robertson Mfg. Co., Buffalo, N. Y. It is designed for use in repair shops, blacksmiths' shops or in any place where power is not

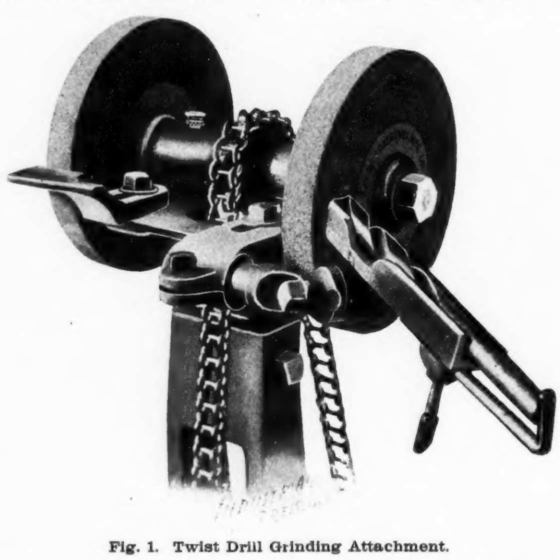


Fig. 1. Twist Drill Grinding Attachment.

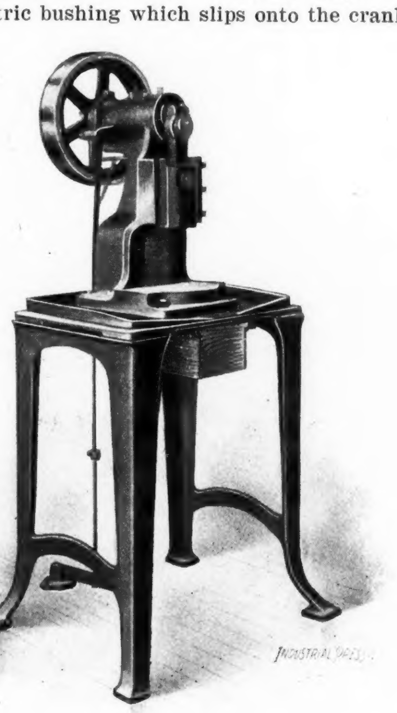
available. It will also prove convenient in the large shops where, at times, a grinder is needed when the power is not in operation. The shaft runs on ball bearings and carries two solid emery wheels 6 inches in diameter and 3/4 inch wide.

The spindle is driven by a chain running over a large driving wheel, which is operated by a crank and foot lever. The head is provided with the ordinary grinding rests and special holders are made for knife and skate grinding. The twist drill grinder, shown in Fig. 1, can be readily attached in place of one of the regular grinding rests.

Fig. 2. "Hero" Foot Power Emery Grinder.

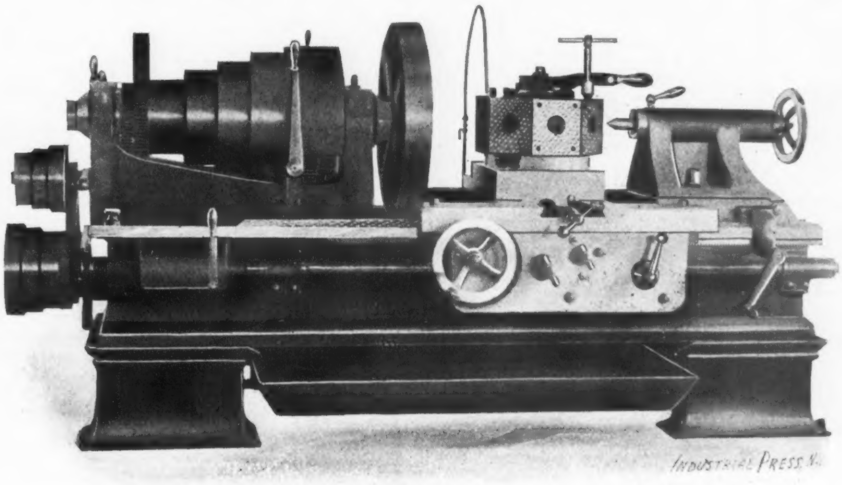
THE "YANKEE" BENCH PRESS.

The half-tone herewith illustrates a form of power press that was originally designed by Mr. Robert C. Manville for light blanking, piercing, clipping, forming and similar work which was formerly done in the ordinary foot and screw presses. The main features that were embodied in the original press are still retained in the new model with such improvements as time and experience have brought about. For the adjustment of the slide to accommodate the different heights of dies and lengths of punches, there is, in the connection, an eccentric bushing which slips onto the crank pin. By loosening this bushing, which is done by simply loosening the screw at the top of the connection, it may be turned so as to obtain any required height.



The "Yankee" Bench Press.

There is a variety of work that has to be placed in position by hand, and in order to do this the press must be brought to a stop at the end of each revolution. In order to make it practically safe for the operator there is provided a combination stop clutch which is so arranged as to render a second revolution of the press impossible without raising the foot. If a continuous motion is required, as with the ordinary power press, it can be obtained by throwing out a trip, which is done by simply turning a screw on the upper end of the treadle connection. These presses are made in two sizes, and may be used on the bench or mounted on an iron table, as illustrated. The builders are the Manville Bros. Co., Waterbury, Conn.



Twenty-eight inch Carriage Turret Lathe, for Valve Work.

TWENTY-EIGHT INCH CARRIAGE TURRET LATHE.

Fay & Scott, Dexter, Me., have lately brought out a 28-inch carriage-turret lathe which is especially fitted for valve work. This is a modification of their regular 28-inch lathe and has double friction back gears and the same style of feed mechanism and lead screw clutches that were described in MACHINERY in March, 1902. In addition to the regular features of the lathe there is mounted on the carriage, in place of the regular tool rest, an octagonal turret having $2\frac{1}{2}$-inch holes, with keyways, for holding boring bars and tools. The faces of the turret are finished and are drilled and tapped, by templet, with a series of holes for fastening special tools or fixtures.

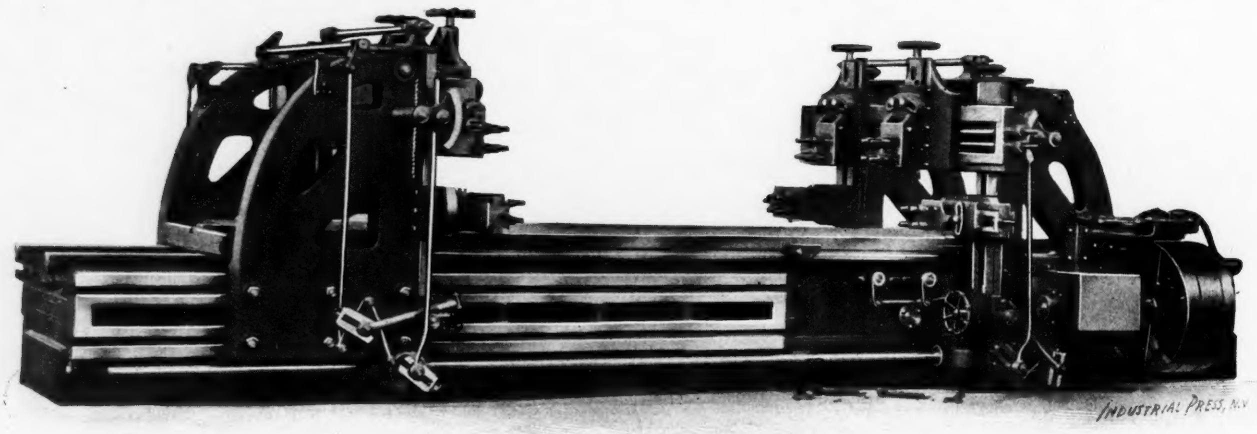
At the top of the turret will be seen the hand lever by which it is operated. A single motion of this lever, forward and back, is sufficient to release the turret, turn the next tool into position and again lock the turret. Being mounted on the carriage, the turret partakes of the regular feeds, both friction and screw-cutting, and may also be used with the cross feed or locked, by dowel pin, so that the holes will come in line with the centers of the lathe. This lathe is mounted on an 8-foot bed with oil pan and pot beneath connected to an oil pump, which is fastened to the back of the lathe and driven from a small pulley on the countershaft. The total weight of the machine is about 8,000 pounds.

LOCOMOTIVE CONNECTING-ROD PLANER.

We illustrate herewith a planer, recently built by the Woodward & Powell Planer Co., Worcester, Mass., that is designed especially to meet the requirements of locomotive builders. The special features of this tool are its simplicity and the adaptability of its design to the special purpose for which it was made. The head housing remains fixed in its position while the rear one can be slid along the bed so that the heads $3\frac{1}{2}$ feet long on connecting rods up to 11 feet in length can be planed with both sets of planer heads in use. The cross rail of each housing carries two heads with an independent power feed for each, and both heads have hand vertical feeds. Four other heads are mounted, one in the face of each housing, making in all eight heads to the machine. These last heads are provided with a vertical power feed and a hand horizontal feed. The belt shifter is a cam device which shifts one belt before the other and is controlled by a hand lever on either side of the bed. There is a device on the rocker for locking the shipper when the belts are on the loose pulleys so that they cannot accidentally work onto the tight pulleys and start the table. Two dogs govern the length of the stroke, and each

has a latch which can be raised to allow the table to be run back either way without changing the position of the dogs.

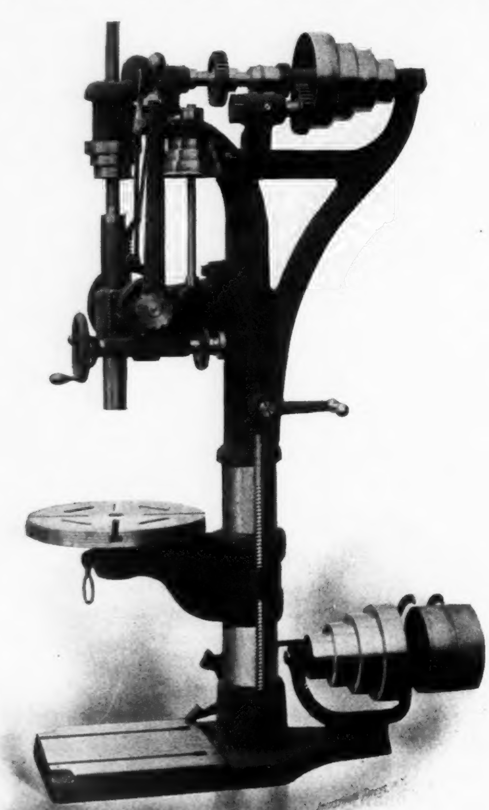
The feed works are very simple, and are designed to give a fine feed or one that is very wide for smoothing cuts. The feed is operated by a positive device, which takes its power from the gearing inside of the bed, so that no load comes upon the shaft except that of moving the heads. The driving gear is such as to give a belt speed of about 90 feet to 1 foot of table movement, the speed being the same forward and back, so that cutting takes place in both directions.



Locomotive Connecting-rod Planer.

TWENTY-INCH UPRIGHT DRILL.

The accompanying illustration shows the latest 20-inch upright drill that has been brought out by the American Tool Works Co., Cincinnati, Ohio. This drill is of new design throughout and has been made heavier and more compact in every way than their former patterns. As shown, it is



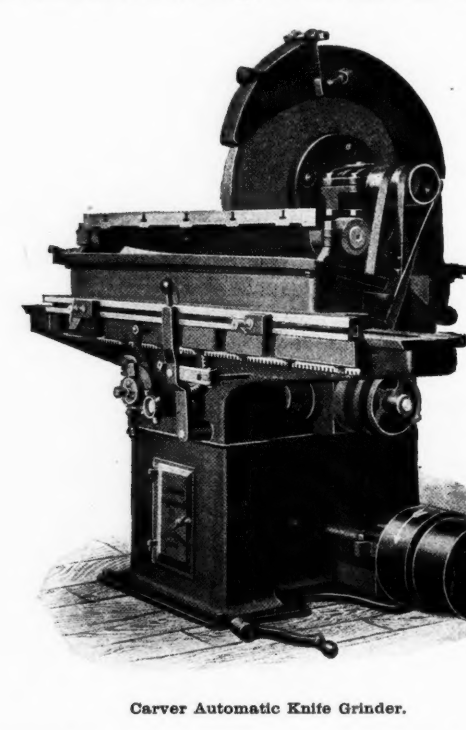
"American" 20-inch Upright Drill.

equipped with wheel, lever and automatic power feeds, back gear and automatic stop. The back gears and automatic feed can be omitted, when desired. The table is raised and lowered by means of a screw and crank. The power feed is engaged or disengaged by a friction which is operated by a conveniently located hand knob. There is an automatic stop to the down feed, which is set by graduations on the spindle and can be readily adjusted. The spindle has a quick return and is counterbalanced.

The back gears, which form a new feature on this size of drill, are engaged very quickly and easily. The belt shifter is so located that the machine can be started and stopped by the foot, leaving the hands free to attend to the work. All levers and handles are placed where they can be easily operated by the workman without changing his position.

THE CARVER KNIFE GRINDER.

The grinder shown in the cut herewith is designed for grinding huller, planer, paper-cutter, or other knives that require a straight and true edge. The knives are fastened to a table which may be set to hold the knife at any angle while the carriage automatically carries it back and forth across the face of the wheel. At the same time the wheel is automatically fed forward onto the knife that is being ground. The pinion that reciprocates the carriage is provided with a clutch which allows either power or hand movements of the



Carver Automatic Knife Grinder.

carriage and permits the carriage to be stopped at any time without stopping the wheel. The length of the stroke is governed by adjusting stops.

The feed can be set to grind fast or fine, as may be desired, and when once set for any piece of work, requires no further attention. When ground to the point for which the index is set, the feed ceases to act so that the knife is not unduly wasted by further grinding. The machine can be used either for wet or dry grinding, and when used for wet grinding

a constant supply of water is furnished from a tank by means of an automatic pump, located on the back of the machine. The water is fed to the wheel by an adjustable hood which prevents it from being thrown off from the wheel and it then returns to the tank where it is used over and over again by the pump. This grinder is the product of the Carver Cotton Gin Co., East Bridgewater, Mass.

KEMPSMITH UNIVERSAL MILLING MACHINE.

Fig. 1 illustrates an entirely new universal milling machine that has just been brought out by the Kempsmith Mfg. Co., Milwaukee, Wis. This machine has been wholly redesigned with a view to fitting it for the higher speeds and coarser feeds

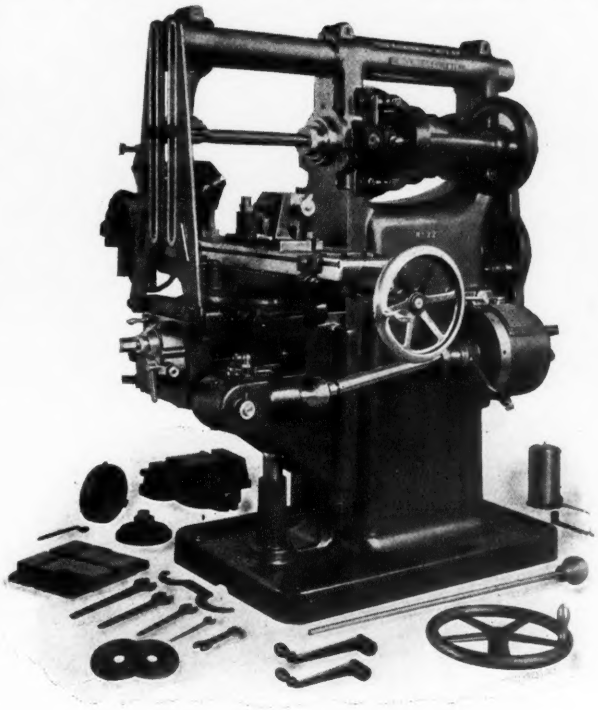


Fig. 1. New Kempsmith Universal Milling Machine.

that are possible with the new tool steels. Besides containing the desirable features of their former machines this miller has new features which not only make it more powerful and rigid but also add to its convenience and ease of operation.

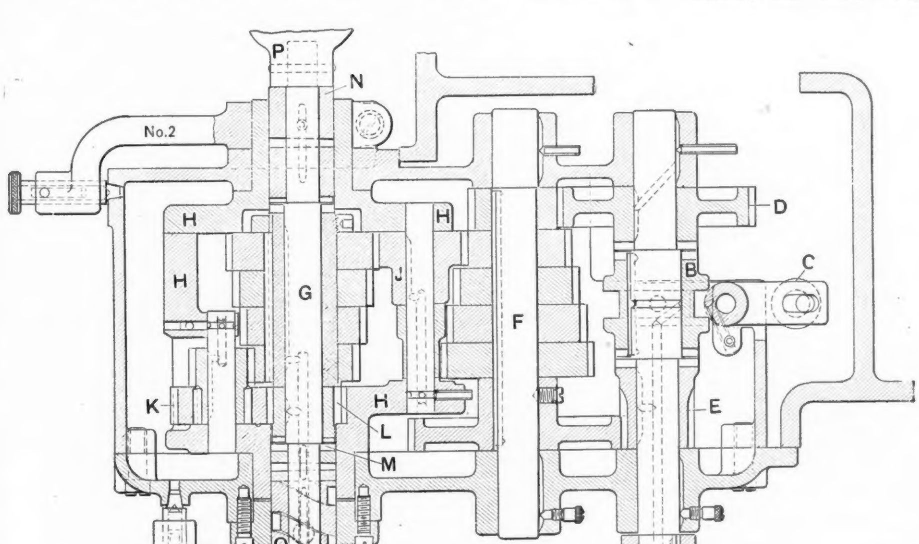


Fig. 2. Diagram of Feed Mechanism of Kempsmith Miller.

The handles for engaging, tripping and reversing all the feeds are at the front of the knee within easy reach of the operator so that he can observe the action on any work in hand and have the movements of the table under absolute control without moving his eyes from the work.

Sixteen spindle speeds are obtained by means of a four-step cone, back gears and double friction countershaft and these, like the table feeds, are arranged in geometrical progression. Fig. 2, which is a view through the center lines of the gear shafts, shows the arrangement of the gearing. Fig. 3 shows that these gear shafts are not in the same plane in the machine but they are so shown in Fig. 2 for the sake of clearness. The feed is direct, driven from the spindle of the machine by means of a chain to sprocket wheel *A* which is keyed to its shaft. *B* is a sliding clutch operated by eccentric shaft *C* and lever No. 1 (Fig. 3) and may be engaged with either *D* or *E*, which in turn will transmit a fast or slow motion to cone gears on shaft *F*. Cone gears corresponding to those on shaft *F* are mounted on shaft *G* in swinging cage *H*. Cage *H* carries four intermediate or idle gears *J* which are made to alternately engage in different pairs of cone gears by means of lever No. 2. Back gear *K* is mounted in cage *H* and drives

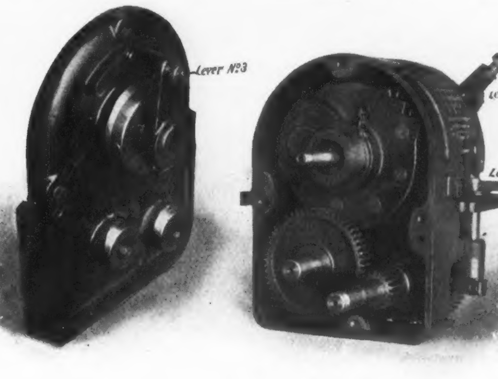


Fig. 3. Feed Box of Kempsmith Miller.

pinion *L*. *M* and *N* are clutches keyed and pinned to shaft *G*. *O* is a sleeve with a helical groove on shaft *G* operated by lever No. 3 to engage either *M* or *N*. *P* is the universal joint connecting with the feed works in the knee through the telescopic shaft. An index plate showing all the feeds from .004 inch to .150 inch per revolution of spindle is attached to feed gear box and indicates the positions of the levers for the desired feed, as the arrangement of the figures and letters on the index plate is in the same direction as the movements of the levers, the feeds may be read instantly.

The straight overhanging arm, heretofore used on the plain miller, has been adopted for use on this machine and this may be pushed back flush with the face of the column when it is desired to place high pieces on the table. The vertical screw is now telescopic and permits lowering knee and table the full distance of feed without need of screw hole in floor or foundation.

NEW INDEX HEAD FOR UNIVERSAL MILLING MACHINE.

The illustrations herewith show a new universal indexing and dividing head, for milling machines, that is made, in three sizes, by the Cincinnati Milling Machine Co., Cincinnati, Ohio. The method of indexing by means of index pointer, plates and connecting gearing is the same as that in general use in mechanisms of this kind. It will make all divisions up to and including 360 and a great many beyond this number. Some of the details are entirely new, particularly the method of taking up the wear between worm and worm wheel and the arrangement for clamping the swivel block at an angle. Angular settings of the work spindle can be made from 5 degrees below the horizontal to 50 degrees beyond the perpendicular when geared to universal machines. When fitted to plain machines, it may be swiveled through a complete circle if the front index plate is removed.

The worm and worm wheel may be thrown out of mesh for any position of the work spindle by turning the T-bolt, Fig. 2, through half a turn, and this is accomplished without removing any parts, slacking up any lock nuts, or disturbing any adjustments whatever. The end of this T-bolt is made eccentric and engages a slide attached to the worm casing, which slide is free to move endwise, and the worm casing itself being confined between the walls of the swivel block, as shown in Fig. 3, can only move in a vertical direction. The slide takes the horizontal motion of the eccentric end of the T-bolt. From this it will be seen that the worm moves away from, or toward the worm wheel in a plane, perpendicular to the axis of the

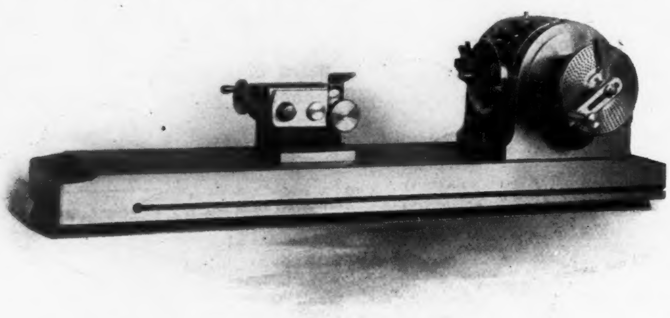


Fig. 1. Index Head of Cincinnati Milling Machine.

worm wheel, that is, a plane through the line *XX*, Fig. 3. Compensation for wear between these two members is obtained by adjusting the screws which attach the slide holder to the worm casing, all of which is evident from Fig. 2. It will be noticed that this compensation for wear is made along the same straight line *XX*, Fig. 3, so that these parts may be adjusted repeatedly without danger of disturbing their alignment.

The swivel block has large trunnions of diameter *A*, Fig. 2, and it is firmly secured in any position by means of the clamping straps shown, which are made to grip the trunnions by tightening two cap screws, one of which is shown in Fig. 3. These trunnion bearings have an arc of contact of 360 degrees; are always fully protected, no part of them being exposed at any time, no matter at what angle the spindle is set. Instead of the usual single notch on the index plate for locking, there is a series of small notches milled on its edge, which permit of moving it a very small amount. This is very often convenient when adjusting work to the cutter. The tailstock has the usual elevating center. It may be set at any angle up to 10 degrees above or below horizontal to bring the centers in line with the center of the work when milling taper reamers or similar work.

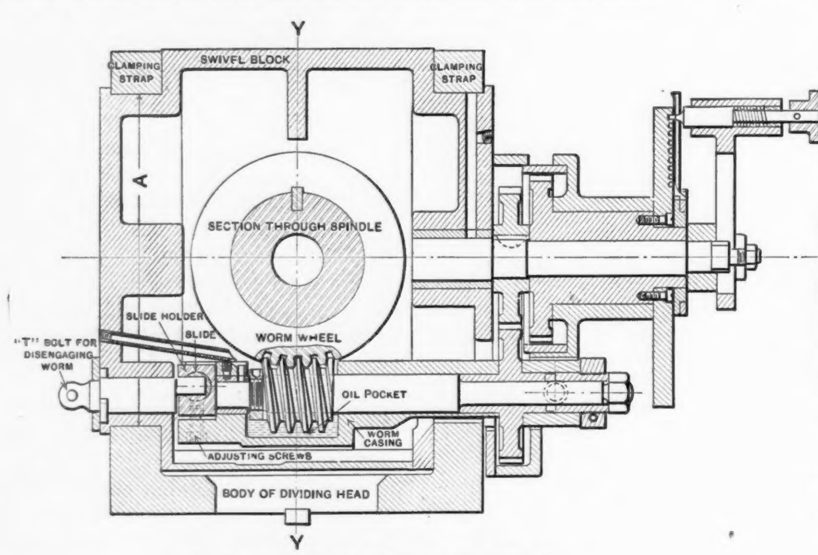


Fig. 2. Cross Section through Index Head.

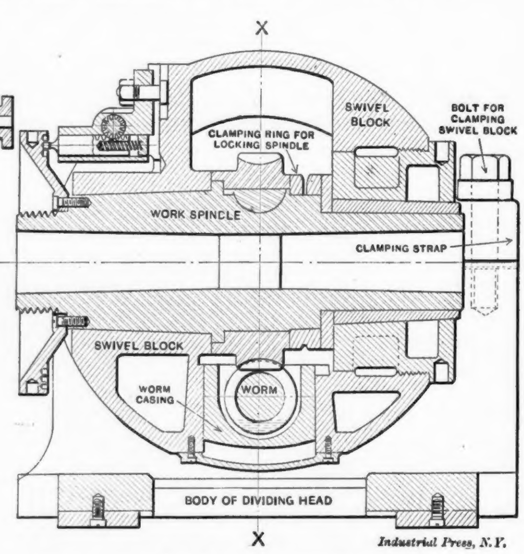
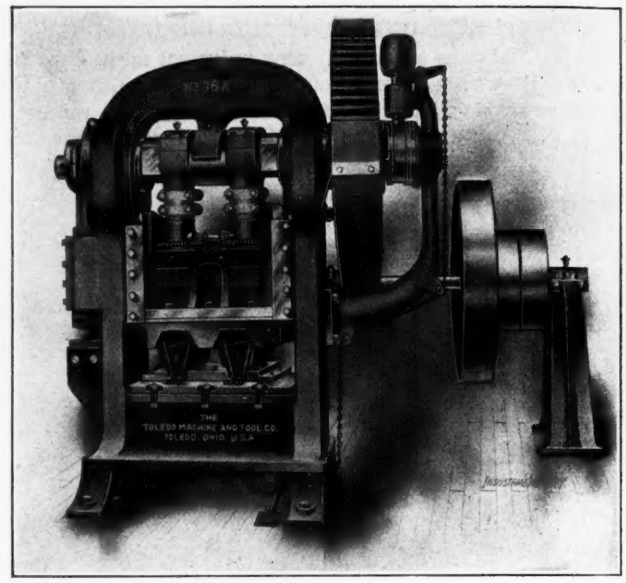


Fig. 3. Longitudinal Section through Index Head.

A NEW FORGING PRESS.

A new type of forging press, that is adapted for general tool forging, is shown in the photograph herewith. As shown, the press is equipped with a special fixture for forging pick-eyes, but this is a separate fixture and may be replaced by one for any other purpose desired, the distance from the bed to the slide being sufficient to accommodate special tools or fixtures for a large variety of forgings.

The press is equipped with outside cut-off which has power for shearing or cutting off bars of considerable size either hot or cold. It has an improved gravity releasing device in which the releasing of the clutch does not depend in any way



New Tool Forging Press.

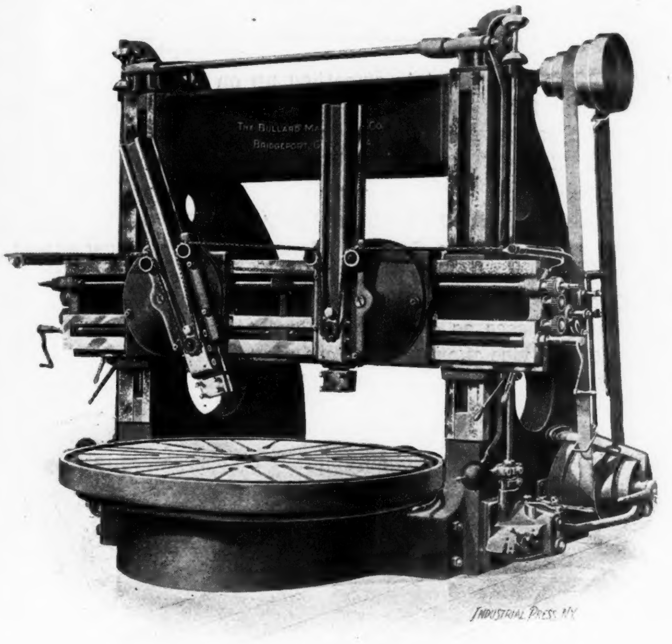
upon springs. By means of this clutch the machine is under control of the operator at all times. The outside trimming attachment may be provided or not, as desired. The press illustrated is provided with adjustable pitmans, but solid ones can be used when they are preferred. The frame is in one piece, thus giving great rigidity. The press is built in three sizes by the Toledo Machine & Tool Co., Toledo, Ohio.

A NEW TEN-FOOT BORING AND TURNING MILL.

The Bullard Machine Tool Co., Bridgeport, Conn., have just placed on the market the new boring and turning mill, of unusually large proportions, that is illustrated herewith. Although rated as a 10-foot mill it has an actual maximum swing of 123 inches, and a maximum height under the cross rail of 84 inches. The machine is driven from a five-step cone by means of a 4-inch belt. The table is turned by a spur pinion running in an internal spur gear, and the intermediate gearing between this pinion and the driving shaft may be manipulated so as to give three different ratios of the driving gear. This, together with the five belt speeds, gives a total of 15 table speeds. The total ratio of the gearing between the driving shaft and table is 252 to 1, so that high belt speeds are employed. To enable the machinist to shift the belt, running at this high speed, swinging guides are placed around each side of the belt so that it may be shifted

from one step to another by a simple movement of levers. All of the driving gears are completely covered with iron casings and are run in a bath of oil. The shifting of the driving gears is all accomplished by levers operated from the side of the machine.

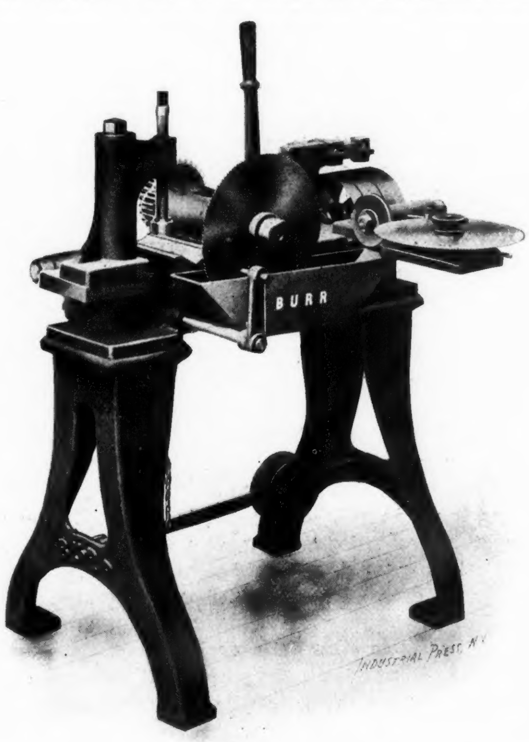
The spindle is 20 inches in diameter by 60 inches long and the lower end runs in an adjustable quartered box so that any



Ten-foot Boring and Turning Mill.

possible chatter or shake may be prevented. The spindle support, which is 50 inches in diameter, is accurately fitted and runs in a bath of oil, the height of which is maintained by means of an indicator placed in a conspicuous position.

Two heads are mounted upon the crossrail and each is driven from an entirely independent mechanism operated from its respective side of the machine. Each head has hori-



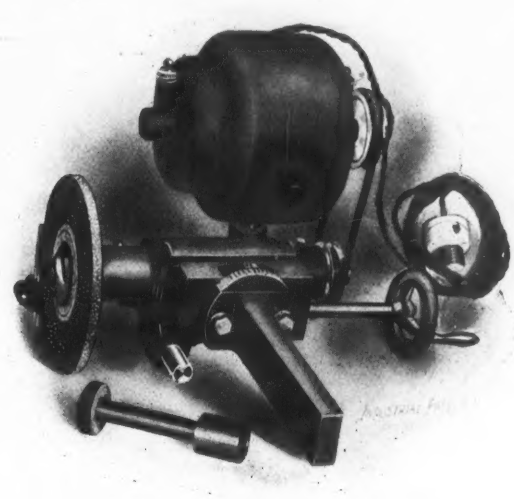
"Burr" Cold Saw with Grinding Attachment.

zontal feed of 1-32 inch to 1 inch and vertical feed of 3-128 inch to ¾ inch, both of which are positive. In addition to this the head on the right-hand side of the machine has a thread-cutting device which cuts threads from 1 to 12 per inch, including the 11½. Each head has a quick traverse, in either direction, driven by friction gearing, which is thrown into operation by the hand lever that may be seen at the side of the machine, fitted with a counterweight for keeping it normally out of action.

The screw-cutting, power and quick feeds are so arranged that putting any one of them in operation places the others out of action so that any accident from interference is impossible. The tool bar has a vertical movement of 48 inches. The crossrail is raised and lowered by power and all of the flat bearings are provided with tapered gibs. The mill, as shown, is belt driven, but when desired it may be operated by a 20 horse power electric motor. The total weight of this machine is somewhat over 90,000 pounds.

ELECTRICALLY-DRIVEN TOOL POST GRINDER.

L. S. Heald & Son, Barre, Mass., have just placed on the market the electrically-operated toolpost grinder shown in the accompanying half-tone. It is adapted for use in the toolpost of either lathe, planer, shaper or milling machine. The motor is mounted just above the spindle and drives it by a round belt running over grooved pulleys. As these pulleys may be changed for others of different diameters any speed of the spindle may be attained, thus fitting the machine for carrying large or small grinding wheels. The tool is provided



Electrically-driven Tool Post Grinder.

with a universally adjustable gage, or rest, for the work and also with an extension spindle for internal grinding. It has an independent feed of three inches by means of a worm and hand wheel. The base, where the grinder is bolted to the holder, is graduated so that the spindle may be set at an angle for grinding tapers. The motor may be wound for alternating, as well as direct current, of any voltage, and the power is supplied by connecting to any convenient incandescent lamp socket.

NEW "BURR" COLD SAW.

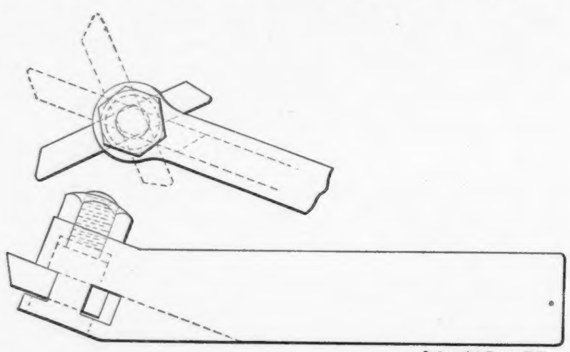
The photograph herewith shows a new cold saw that has just been placed on the market by John T. Burr & Son, Brooklyn, N. Y. This machine uses a 10-inch circular milling saw 1-16 inch thick, and has a capacity for cutting off stock up to 3½ inches, round or square. It is operated by means of a pair of cut pinions, worm wheel and worm. The saw carriage or slide is fed by gravity, the weight being adjustable on the lever and the movement being transmitted to the carriage by a chain running over a grooved sleeve. The vise and vise arch may both be removed from the frame and fixtures for cutting special work substituted.

The saw runs in a bath of oil and a stock stop provides for cutting any number of pieces to the same length. The machine is especially adapted to cutting up disks, gears, collars, etc., and for any work where it is desired to have the ends parallel. It is claimed that it will cut off to within .005 inch of parallel. The machine is furnished with a saw grinding attachment which is operated by a pulley on the driving shaft. For the purpose of illustration a saw is shown both on the saw arbor and also in position to be ground.

FOUR NEW LATHE TOOLS.

COMBINATION STRAIGHT AND SIDE TOOL HOLDER.

The tool holder illustrated herewith is manufactured by Carr Bros., Syracuse, N. Y. It is, in a way, a combination of three tools, taking the place of a right-hand, left-hand and straight holder. The cut shows the blade in one of the side positions while the dotted lines show how it can be turned to the other

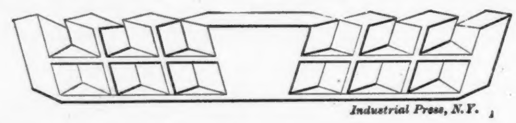


Industrial Press, N. Y.

hand or straight. The blade is locked in its position by the nut on the top and the angle of the clamp is such as to give the proper rake without top grinding. When in the off-set position it has an additional rake, as this position raises the cutting edge.

MULTIPLE DIAMOND-POINT TOOL.

A novelty in the way of a diamond-point tool is shown in the sketch herewith. The tool is drop-forged and has three points at each end connected by webs, and as each point becomes ground away so that it is no longer useful, it is broken

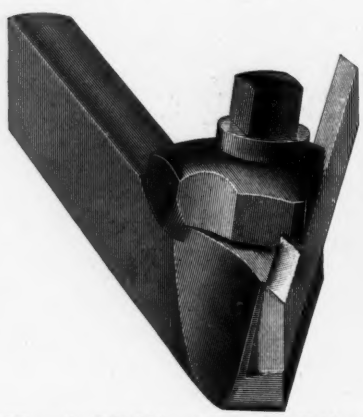


Industrial Press, N. Y.

off and the next point is smoothed up on the grinder and is then ready for business. In this way practically the whole of the steel comprising the tool is available for use. The tool is made by the Jaques-Bush Mfg. Co., Providence, R. I.

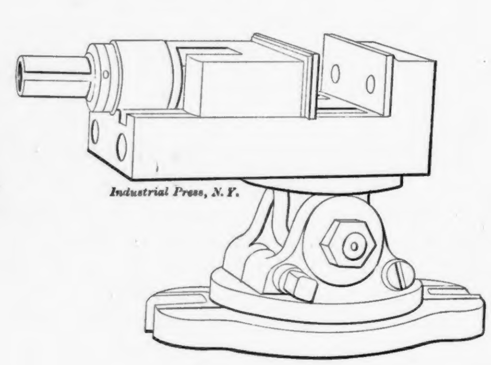
TWO TOOLMAKERS' VISES.

The Atlas Machine Co., Providence, R. I., have just placed on the market two new vises designed especially for holding work at angles in the planer or milling machine and for such similar purposes as occur in general toolmaking work. The body of the vise shown in the cut may be tipped and clamped at any angle up to 55 degrees and may also be swung around the base in a complete circle. A series of graduations on the base, in connection with a pointer, indicate the angle at which the vise is set, while a clamping bolt retains it firmly in position. Both jaws have hardened steel plates which are held



"Champion" Right-hand Side Tool Holder.

A New Corundum Wheel.



Industrial Press, N. Y.

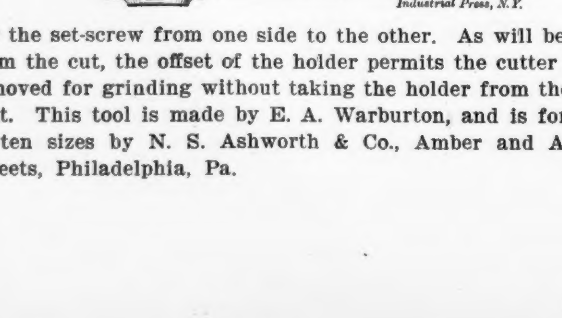
"Atlas" Toolmakers' Vise.

"CHAMPION" SIDE TOOL HOLDER.

This tool holder is designed for facing work and also forms a convenient tool for turning or reducing stock. The cutter is supported both on the side and bottom and is held by a wedge shaped cap that clamps it firmly in place. This holder is made both right and left hand, the one shown in the cut being the right hand tool. It is made in three sizes and is the product of the Western Manufacturing Co., Springfield, O.

RIGHT AND LEFT HAND OFF-SET TOOL.

This tool is designed for using extra large cutters made of self-hardening tool steel and is made very rigid to stand the excessive strains which are encountered in heavy work. It is fitted for use on lathe, planer or shaper and may be used either as a right or left-hand tool, as desired, by simply chang-



Industrial Press, N. Y.

ing the set-screw from one side to the other. As will be seen from the cut, the offset of the holder permits the cutter to be removed for grinding without taking the holder from the tool post. This tool is made by E. A. Warburton, and is for sale in ten sizes by N. S. Ashworth & Co., Amber and Adams Streets, Philadelphia, Pa.

in place by screws so that removal and change from the rough to smooth jaws is the work of but a few minutes. The other vise is similar in construction, but is provided with the rotary movement only, the jaws remaining fixed in a horizontal plane. In this vise a screw is provided for locking the table in any desired position.

A NEW CORUNDUM WHEEL.

The Vitrified Wheel Co., Westfield, Mass., have for some time been turning their attention to the corundum that has been found in large quantities in Canada, and their investigations and experiments have developed the fact that this corundum is unusually pure and efficient and that its cutting and lasting qualities are quite remarkable. An analysis of this abrasive shows that it contains 95 per cent. of pure corundum. The company is now placing on the market wheels made from this Canadian corundum obtained from the "Craig" mine, which are claimed to be very rapid cutting wheels. Owing to the absence of non-cutting properties these wheels will not glaze. Experiments in grinding tough and hard steel have shown that there is an almost entire absence of heat generated either in the wheel or in the material being ground. This shows that instead of having to crowd the work against the wheel until it reaches an extreme heat, the wheels cut so rapidly that the work is completed without creating enough friction to cause heating.

* * *

NEW TRADE LITERATURE.

THE EMERSON ELECTRIC MFG. Co., St. Louis, Mo. Advertising card calling attention to the "Emerson" fan motors, and especially to desk fans for office use.

THE W. C. YOUNG MFG. Co., Worcester, Mass. Catalogue of lathes, punches and shears. The 9, 10, 12, 13 and 14-inch engine lathes are shown, and also a set of lathe tools.

THE CHALLENGE MACHINE Co., 3223 Turner St., Philadelphia, Pa. Booklet calling attention to the "Challenge" emery grinders and illus-